Preliminary Assessment

Goodrich Asbestos Impoundment
EPA ID: OKN000605314
Miami, Ottawa County, Oklahoma

December 31, 2020

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100022745

Table of Contents

Goodrich Asbestos Impoundments Preliminary Assessment

I. Introduction

The State of Oklahoma Department of Environmental Quality (DEQ) is tasked by the U.S. Environmental Protection Agency (EPA), as authorized by CERCLA and as amended by SARA, under the Multi-Site Cooperative Agreement (CA# V-01F02701) to conduct a Preliminary Assessment (PA) of part of the B.F. Goodrich Asbestos site in Miami, Ottawa County, Oklahoma, (EPA ID# OKN000605314 in the SEMS database). The former retention ponds of the closed and razed B.F. Goodrich tire manufacturing plant are the focus of this PA. This PA will assess the immediate or potential threat of waste at the site that may impact public health and the environment and collect information sufficient to support a decision regarding the need for further action under CERCLA/SARA. The scope of this investigation includes the review of available information from DEQ and other state agencies' files, a comprehensive target survey, an onsite reconnaissance.

II. Site Description, Operational History, and Waste Characteristics

Site Description

The Goodrich Asbestos Retention Impoundment is located in a rural/agricultural area approximately ¼ mile east of P Street NW and approximately ½ mile north of Goodrich Blvd., Miami, Ottawa County, Oklahoma. A tract of land lying in the N½ SW¼ and the S½ NW¼ of Section 24, Township 28 North, Range 22 East of the Indian Meridian, Ottawa County and has the coordinates of 36.889124° north Latitude and 94.889013° west Longitude. The site retention impoundment (it will be referenced as Impoundment for the rest of the document) was formerly a large flow-through water holding structure that was part of the former B.F. Goodrich tire manufacturing facility operations. The site is approximately four acres in size. It is surrounded by woodlots and pasturelands. the former B.F. Goodrich (BFG) tire manufacturing facility is immediately to the south of the Impoundment. The City of Miami solid waste transfer facility is approximately 500 feet north of the Impoundment (Figures 1 & 1A).

Ottawa County is in the Central Lowland physiographic province. The summers are hot, and the winters are cool. The average annual temperature is 59 degrees. The mean annual precipitation is 45 inches with precipitation falling, in a yearly average, 87 days a year. The average annual runoff is approximately 7 – 12 inches (References 2 & 8).

The Impoundment was formerly owned and operated by the B. F. Goodrich tire manufacturing facility. The tire plant closed February 28, 1986. The current owner of the property is REAL ESTATE REMEDIATION. LLC, a foreign, limited liability company whose address is 3519 Greensboro Avenue, Tuscaloosa Alabama, 35401. ALLAN KASPAR was the former owner and sold the property to REAL ESTATE REMEDIATION on April 10, 2020 for $10.00 (Reference 6). DEQ was unable to perform a standard county records ownership search because of COVID-19 pandemic restrictions and protocols.

There may be Environmental Justice concerns based on level of income and number of children under the age of five years of age (Reference 9).

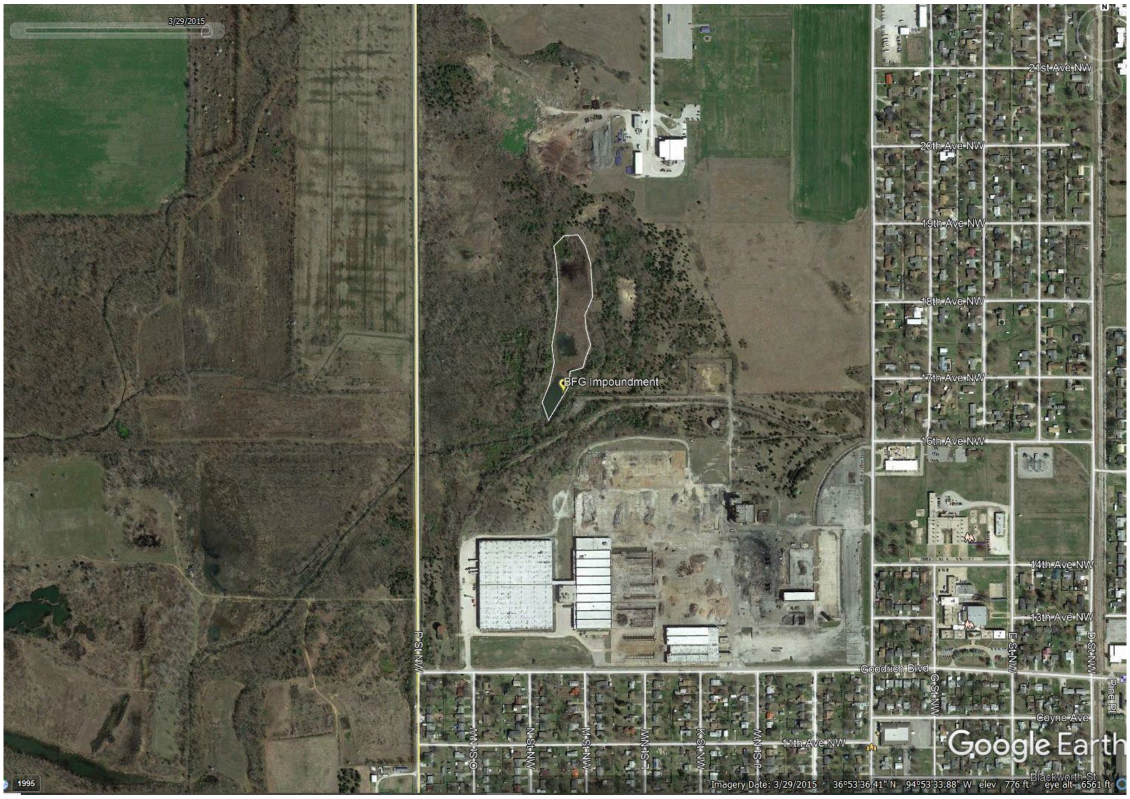


Figure 1. Remote image of Impoundment and environs, northwest City of Miami, Ottawa County.

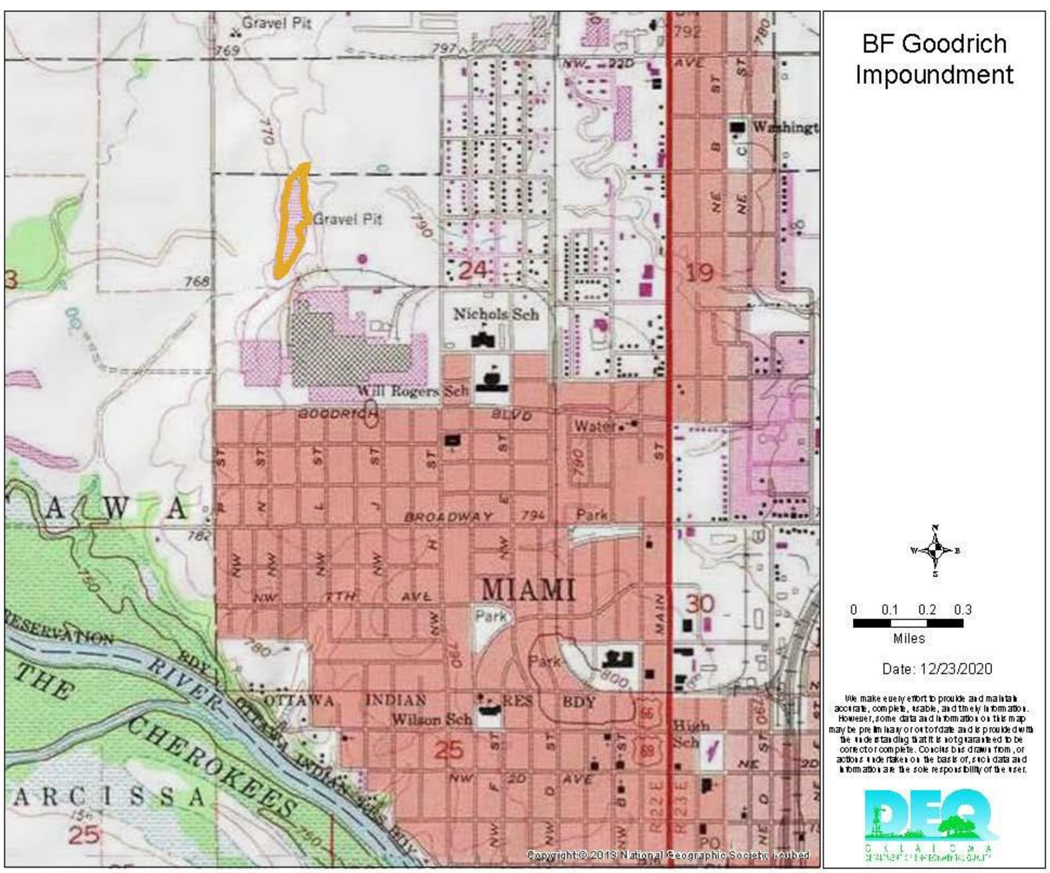


Figure 1A. Topographic map of Impoundment and environs, northwest City of Miami, Ottawa County.

Operational History

The B.F. Goodrich Asbestos Impoundment was formerly owned by and operated by B.F. Goodrich as a large flow-through impoundment structure to the north of the former tire manufacturing facility and was the main permitted discharge impoundment for stormwater and industrial wastewater from the BFG operations. The exact substances sent to the Impoundment is unknown but based on the history of the B.F. Goodrich manufacturing history it is possible for a variety of metals, semi-volatile organic and volatile organic chemicals to have been in the wastewater and stormwater that was pumped into the Impoundment (Reference 1).
A description of the impoundment by a DEQ Water Quality engineer that visited the site: "*The large flow-through impoundment to the North was the main discharge impoundment for stormwater and industrial wastewater from BFG. This impoundment has not been closed or addressed, nor do I think most people are aware of it being out there. My understanding, from my site visit out there back in 2017, is that this flow-through impoundment is on the property owned by the property owner to the North, and it is "not" considered part of the property that was recently purchased by the city of Miami. However most, if not all, the BFG site stormwater is currently flowing to the impoundment and then to the Neosho River via the old BFG stormwater and industrial wastewater system. The Impoundment berms have been compromised by deep rooted vegetation. The large outfall structure is still on site, but it is being bypassed by water flowing out of the impoundment into the unnamed tributary of the Neosho River."*

Previous Investigations

No records of previous investigations of the Impoundment were found. The BFG former manufacturing facility has numerous ongoing environmental investigations, an EPA Emergency removal action and a DEQ VCP Consent Order. There are no complaints on records within the DEQ system for the Impoundment.

Waste Characteristics

The Impoundment was an integral part of the BFG facility operations as the main retention structure for stormwater and industrial wastewater. Wastes should preponderantly be those associated with the manufacturing of tires (Reference 1).

III. Pathway and Environmental Hazard Assessment

Groundwater Pathway

<u>Geology</u>

Ottawa County is in the Central Lowland physiographic province. The summers are hot, and the winters are cool. The mean annual precipitation is 45 inches, and the average annual runoff is approximately 7 – 12 inches.

The Goodrich Impoundment sits on the Pennsylvanian-age McAlester and Hartshorne Formations. The McAlester Formation consists of dark gray to medium gray, well-laminated, concretionary, silty, clay shale. The base of the formation is the Warner Sandstone unit. It is predominantly a dusky yellow color, planar laminated to thin-bedded, fine-grained siliceous sandstone. Overall thickness of the McAlester Formation is approximately 350 feet.

The McAlester Formation is underlain by the Hartshorne Formation. The Hartshorne Formation is dark gray to medium dark gray, well-laminated to fissile, slightly silty clay shale. Rare coal beds with under clay and concretionary horizons occur locally in the upper part of the unit. Thickness ranges from about 75 – 80 feet.

Hydrogeology

Shallow groundwater beneath the ponds is found approximately 10 – 20 feet below ground surface. The general direction of flow is southward toward the Neosho River. Except for the Warner Sandstone member at the base of the McAlester Formation, the McAlester and Hartshorne Formations yield only small amounts of fair to poor quality water. The Warner Sandstone probably will yield small to moderate amounts of fair-quality water locally.

The Impoundment is in the potential recharge area for the Keokuk and Reed Springs (or Boone) Formation and Roubidoux Formation bedrock aquifers. The Keokuk and Reed Springs Formation is approximately 200 feet below ground surface. Thickness ranges from about 250 – 400 feet, and wells producing from this aquifer commonly yield 3 – 50 gallons per minute (gpm) of water that is of good quality (generally less than 500 mg/L dissolved solids). The Roubidoux thickness generally ranges from 200 – 500 feet and averages about 150 feet. The aquifer is located approximately 500 – 1,500 feet below ground surface. Wells commonly yield 50 – 250 gpm, and the water is of good to fair quality generally 150 to 1,500 mg/L dissolved solids (Reference 8).

Groundwater Pathway Targets

According to the Oklahoma Safe Drinking Water Information System (SDWIS), the public water system of Miami is serviced by nine, active public supply wells. The closest two public water supply wells are located 1.72 miles southeast and 1.83 miles east of the Impoundment respectively. The wells reach water at approximately 400 – 500 feet below ground surface. The population served by the public water system is approximately 13,704 residential people and 433 working people (Reference 4). A City of Miami industrial supply well is 0.75 miles northeast of the Impoundment and is the closest groundwater use well to the site

The table below depicts the number of private groundwater wells within a 4-mile radius of the site. The nearest private groundwater well is approximately 2.17 miles north northeast of the site. (Reference 4). The estimated population served by private wells is calculated by multiplying the number of wells by the average number of persons per household in Miami (2.56) (Reference 9).

Table 1

Distance from Site	**Number of Wells**	**Est. Population Served by Private Wells**
Onsite	0	0
0 - ¼ mile	0	0
¼ - ½ mile	0	0
½ - 1 mile	0	0
1 - 2 miles	0	0
2 - 3 miles	3	9
3 - 4 miles	4	12
Total	7	21

There are no underground storage tanks (UST) onsite. Within a 1-mile radius of the site, there are approximately 12 USTs. Three are regulated by the Oklahoma Corporation Commission and nine are unregulated. The closest UST at Pump N Petes #17 is located approximately 4500 feet east of the site on Main Street and it is the only one that is in use. All the others within the radius are defined as permanently out of use (Figure 5). There are 73 total USTs within four miles of the Impoundment. 20 are open and 53 are closed (Figure 5).

Soil

Soil information was gathered using the U.S. Department of Agriculture's Custom Soil Survey (Figure 7). The table below depicts the soil types found at and around the Impoundment. The Area of Interest (AOI) is arbitrary for investigation purposes. Impoundment is focus of PA.

Soils Associated with the BFG Impoundment AOI

Map Unit	Percent slopes	Composition	Landform	Typical Profile	Natural Drainage Class	Water Transmission
Ln-Lightning silt loam Acres in AOI: 17.9 Percent of AOI: 38.8%	0 to 1	Lightning and similar soils	Flood-plain steps	0 to 7 inches: silt loam 7 to 14 inches: silt loam 14 to 22 inches: silty clay loam 22 to 62 inches: silty clay 62 to 79 inches: silty clay	Poorly drained	Low to moderately high Occasional flooding
PaB-Parsons silt loam Acres in AOI: 15.8 Percent of AOI: 34.1%	1 to 3	Parsons and similar soils	Divides	0 to 8 inches: silt loam 8 to 14 inches: silt loam 14 to 24 inches: silty clay 24 to 59 inches: silty clay 59 to 79 inches: silty clay loam	Somewhat poorly drained	Very low to moderately low
Prqg- Pits, gravel and quarry	1 to 3	Pits, gravel and quarry	Pits, gravel and quarry	Not defined	Not defined	Not defined

Groundwater Pathway Conclusion

The City Miami drinking water is supplied by nine active public supply wells. Each well is also a wellhead protection area. There are 24 public and private water supply wells within four miles of the Impoundment. There are records of an industrial supply well (OWRB designation 41468) on site that was installed in 1944. Due to the existence of public water wells, the groundwater pathway is considered a potential pathway of concern for the site.

Surface Water Pathway

Within the site boundary, an overflow/discharge ditch exits the south end of the Impoundment and flows westward to exit the property at P Street. From there, the water leaving the Impoundment can flow eventually to the Neosho River. The distance from the impoundment outfall to P street is 730 Feet. From P Street to the Neosho River it is approximately, straight line, 4200 feet (Figures 2 and 2A). The distance of the ditch from the Impoundment to where it empties into a pond west of P Street is roughly 4000 feet following the apparent course of the ditch on aerial images. From the pond where the unnamed creek that flows out of the pond enters the Neosho River following the apparent course of the un-named, intermittent creek is approximately 4120 feet. So, though the Impoundment is within 4500 direct line feet of the river the distance water leaving the Impoundment travels to reach the Neosho River is approximately 8600 feet or 1.63 miles. The site is in a special flood hazard area (SFHAs) and is subject to inundation by the 1% (100-year flood) annual chance flood (Figures 9A, 9B and 9C, Reference 3).

This expected probable point of entry (PPE) is the point the water from the Impoundment enters the ditch. The USGS Miami NW Topographic map classes the ditch and the creek the ditch empties into as intermittent so that there is no perennial connection between the Impoundment and the Neosho River (Figures 2 and 2A). Also see Photographs 1 and 2.

Within the 15-mile Target Distance Limit (TDL), the outflow ditch flows west, then southeast via an un-named creek into the Neosho River. From where the un-named, intermittent creek enters the Neosho, it is 14.25 miles downriver to Grand Lake O' The Cherokees. There are no Public Water Supply intakes within 15 miles of the Impoundment. The closest intake is 19 miles direct line distance and 34 river miles away (Reference 4).

The acreage of wetlands within a four-mile radius of the site is delineated in Table 1 below. Most wetlands/hydric soils are associated with the Neosho River. Viewing an aerial image of the Impoundment it is noted that large majority of the soils to the west of the site are classed as hydric soils. A hydric soil is a soil that formed under conditions of saturation, flooding or ponding long enough during the growing season to develop anaerobic conditions in the upper part. These areas are often classed as wetlands. Although the Impoundment is not within a hydric soil area the ditch that drains the Impoundment is, for most of the distance in its path to the Neosho (Figure 9C, Reference 3).

Table 1 – Wetlands

Distance from site (miles)	Estimated Wetland Acreage*
0 - .25	19.433
0 - 0.5	153.284
0 - 1	1,330.138
0 - 2	3,266.262
0 - 3	4,304.659
0 - 4	5,326.826

Surface Water Pathway Targets

The tables below list the species that are threatened or endangered in Ottawa County based on Oklahoma Department of Wildlife Conservation data (References 10).

Table 2 – Ottawa County State Endangered and Threatened Species

Species
Neosho Mucket (Lampsilis rafinesqueana) aka Neosho Pearly Mussel

Ottawa County Federal Endangered and Threatened Species

Species and Status
Gray Bat (Myotis grisescens) – endangered
Ozark Big-eared Bat (Corynorhinus (= Plecotus) townsendii ingens) - endangered
Piping Plover (Charadrius melodus) – threatened
Interior Least Tern (Sterna antillarum) - endangered
Neosho Madtom (Noturus placidus) – threatened
Ozark Cavefish (Amblyopsis rosae) - threatened
Arkansas Darter (Etheostoma cragini) – candidate species under evaluation

A search of the U.S. Fish and Wildlife Service revealed threatened or endangered species that may or could potentially be affected by activities on the site (Reference 10). The table below summarizes the Federal Environmental Conservation Online System (ECOS) information.

Table 3 – National Wildlife Service ECOS genus species list for Oklahoma

Scientific Name	Common Name	ESA Listing Status
Myotis sodalis	Indiana bat	Endangered
Myotis grisescens	Gray bat	Endangered
Corynorhinus (=Plecotus) townsendii ingens	Ozark big-eared bat	Endangered
Grus americana	Whooping crane	Endangered
Charadrius melodus	Piping Plover	Threatened
Percina pantherina	Leopard darter	Threatened
Amblyopsis rosae	Ozark cavefish	Threatened
Noturus placidus	Neosho madtom	Threatened
Notropis girardi	Arkansas River shiner	Threatened
Quadrula fragosa	Winged Mapleleaf	Endangered
Arkansia wheeleri	Ouachita rock pocketbook	Endangered
Leptodea leptodon	Scaleshell mussel	Endangered
Quadrula cylindrica cylindrica	Rabbitsfoot	Threatened
Lampsilis rafinesqueana	Neosho Mucket	Endangered
Alligator mississippiensis	American alligator	Threatened
Calidris canutus rufa	Red knot	Threatened
Myotis septentrionalis	Northern Long-Eared Bat	Threatened
Laterallus jamaicensis ssp. jamaicensis	Eastern Black rail	Threatened

U.S. Fish and Wildlife Service reclassified the American Burying Beetle from endangered to threatened and finalized the rule under section 4(d) of the Endangered Species Act to provide for the conservation of the species (85 FR 65241). The final rule was effective November 16, 2020.

Surface Water Pathway Conclusion

The exact substances that were historically sent to the Impoundment is unknown but based on the history of the B. F. Goodrich manufacturing history it is possible for a variety of metals, semi-volatile organic and volatile organic chemicals to have been in the wastewater and stormwater that was pumped into the Impoundment. (Reference 1). Surface water that collects in the Impoundment flows out of the outfall and into the ditch that runs westward to the boundary of the property on P Street. The ditch continues southwestward approximately 0.76 miles to eventually flow into a wetlands/intermittent pond. An un-named creek flows into and out of the wetland continuing southeastward roughly 0.78 miles to debouch in the Neosho River. Within the 15-mile TDL, the Neosho River flows south and eastward into Grand Lake O' the Cherokees. Contaminants from the materials deposited in the Impoundment during the facilities operation may migrate into the ditch, intermittent un-named creeks, wetlands and the Neosho River, downstream of the site. The surface water migration pathway is an expected pathway of concern.

Soil Exposure Pathway

Physical Condition

This PA is focused only on the Impoundment. The Impoundment holds changeable levels of water dependent upon recent precipitation amounts (Figures 3A through 3F historical imagery). The Impoundment is approximately four acres in size and can be accessed from all sides as there is only barbed-wire fences to restrict trespass.

Soil Exposure Pathway Targets

The site is surrounded by woodlots and pasturelands. the former B.F. Goodrich (BFG) tire manufacturing facility is immediately to the south of the Impoundment (Figure 1 & 1A).

Current aerial images show there are no residential homes within 200 feet of the Impoundment (Figures 4A and 4B). According to the United States Census Bureau Quickfacts, the average number of persons per household in Miami is approximately 2.56 (Reference 9). The estimated population within a one-mile radius of the site is estimated to be 4320 people (Reference 9).

Soil Exposure Pathway Conclusion

The Impoundment holds changing levels of water dependent upon recent precipitation amounts. The exact substances that were sent to the Impoundment is unknown but based on the history of the B. F. Goodrich manufacturing history it is possible for a variety of metals, semi-volatile organic and volatile organic chemicals to have been in the wastewater and stormwater that was pumped into the Impoundment (Reference 1). The site is not secured and subject to potential trespassing. The soil exposure pathway is an expected pathway of concern.

Air Pathway

A particulate release to air is possible from the contaminated source, but no active release was noted during the site reconnaissance. The site is not located adjacent to a residential area.

Air Pathway Targets

No one lives on site. The estimated population and wetland acreage within a 4-mile radius of the site is described in the Table 4 below (Reference 4).

Table 4 – Estimated Population and Wetlands

Distance from Site	Population (persons)	Area (acres)
0 - .25	0	19.433
0 - 0.5	897	153.284
0 - 1	4320	1,330.138
0 - 2	11451	3,266.262
0 - 3	15118	4,304.659
0 - 4	17566	5,326.826

Endangered and Threatened Species

U.S. Fish and Wildlife Service and Oklahoma Wildlife Conservation Department endangered and threatened classified species are listed in Tables 2 and 3 (Reference 10).

Air Pathway Conclusion

A particulate release to air is suspected from any contaminated source, but no active release was noted during the site reconnaissance. The air pathway is not expected to be a pathway of concern for the site.

VI. Summary and Conclusion

The Goodrich Asbestos Retention Impoundment is located in a rural/agricultural area approximately ¼ mile east of P Street NW and approximately ½ mile north of Goodrich Blvd., Miami, Ottawa County, Oklahoma. It has the coordinates of 36.889124° north Latitude and 94.889013° west Longitude. The site is approximately four acres in size. It is surrounded by woodlots and pasturelands. The former B.F. Goodrich (BFG) tire manufacturing facility is immediately south of the Impoundment. The B.F. Goodrich Asbestos site retention impoundment formerly operated as a large flow-through impoundment structure for the former B.F. Goodrich tire manufacturing facility and was the main permitted discharge impoundment for stormwater and industrial wastewater from the BFG operations. The exact substances that were sent to the Impoundment during it operation are unknown but based on the history of the B.F. Goodrich manufacturing history it is possible for a variety of metals, semi-volatile organic and volatile organic chemicals to have been in the wastewater and stormwater that was pumped into the Impoundment. The Impoundment property is not secured and subject to potential trespassing. An overflow/discharge ditch exits the south end of the Impoundment and flows westward to exit the property and from there the potentially contaminated water leaving the Impoundment can eventually flow to the Neosho River.

As a result of the information gathered during this PA, a Site Inspection (SI) of the Goodrich Asbestos Retention Impoundment site is recommended to further investigate the groundwater, surface water and soil pathways of concern.

VII. FIGURES

Figure 1. BFG Impoundment and environs

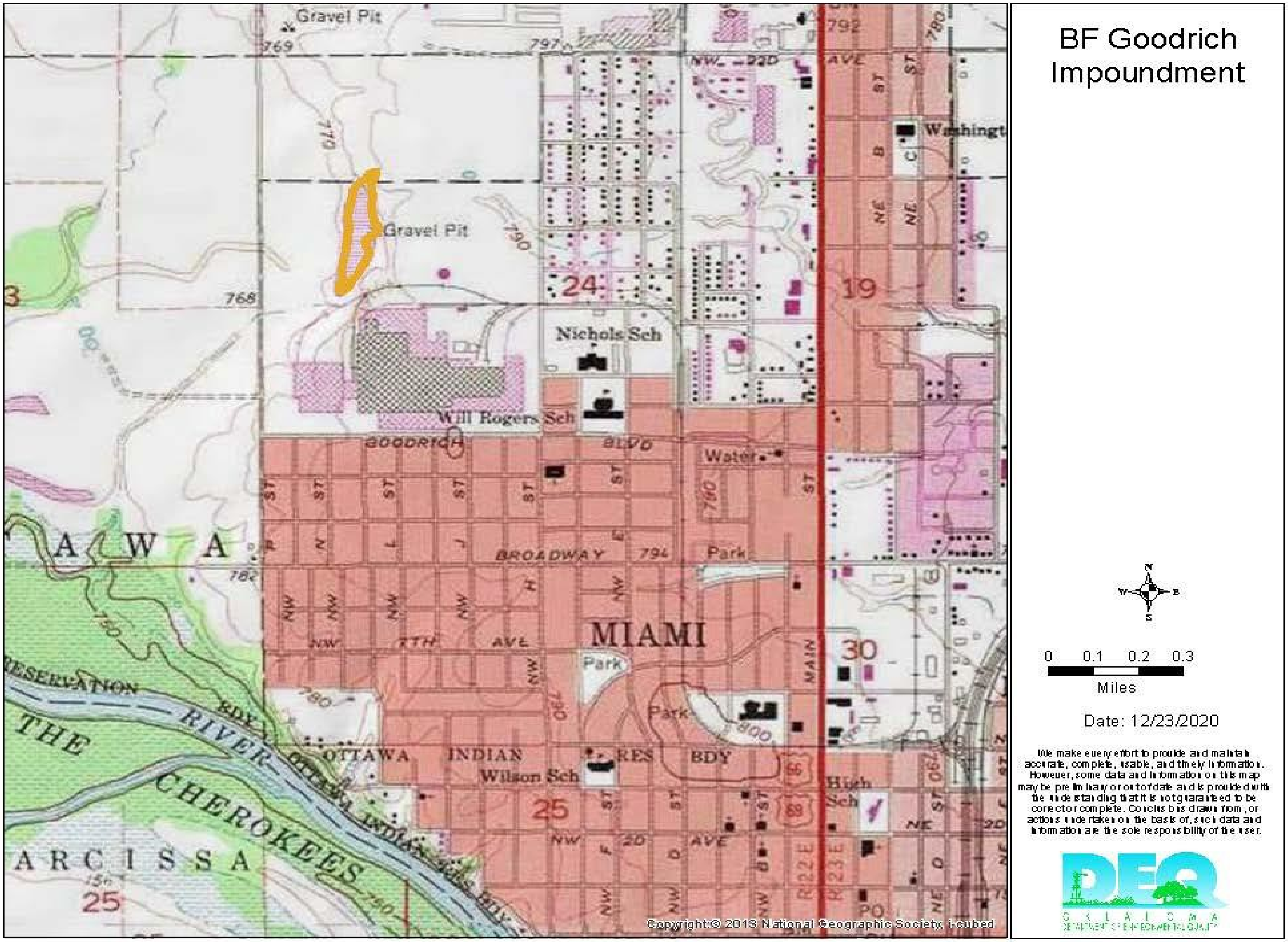


Figure 1A. BFG Impoundment and environs – Topographic Map

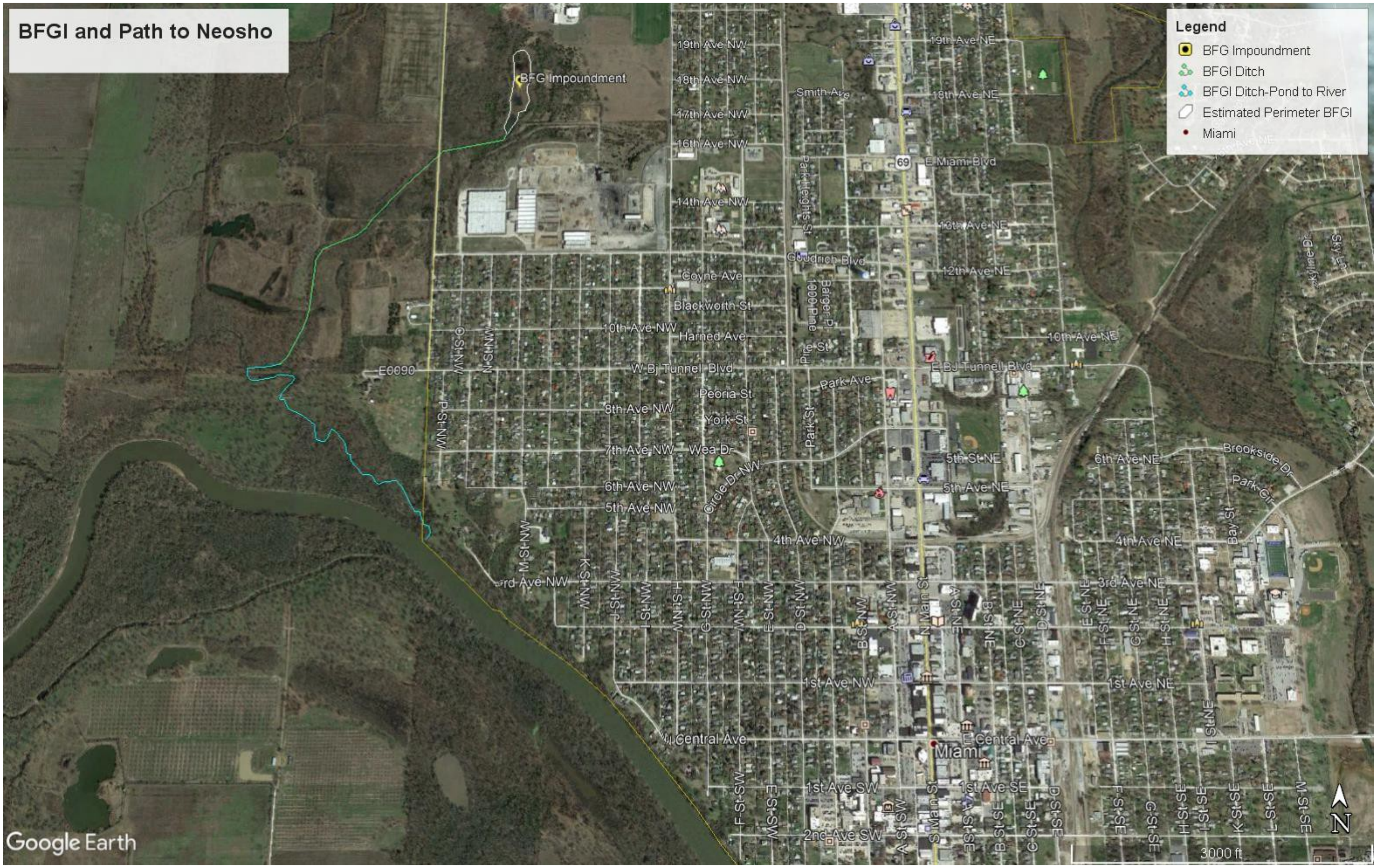


Figure 2. BFG Impoundment and path of water from Impoundment to Neosho River – 2015 Image

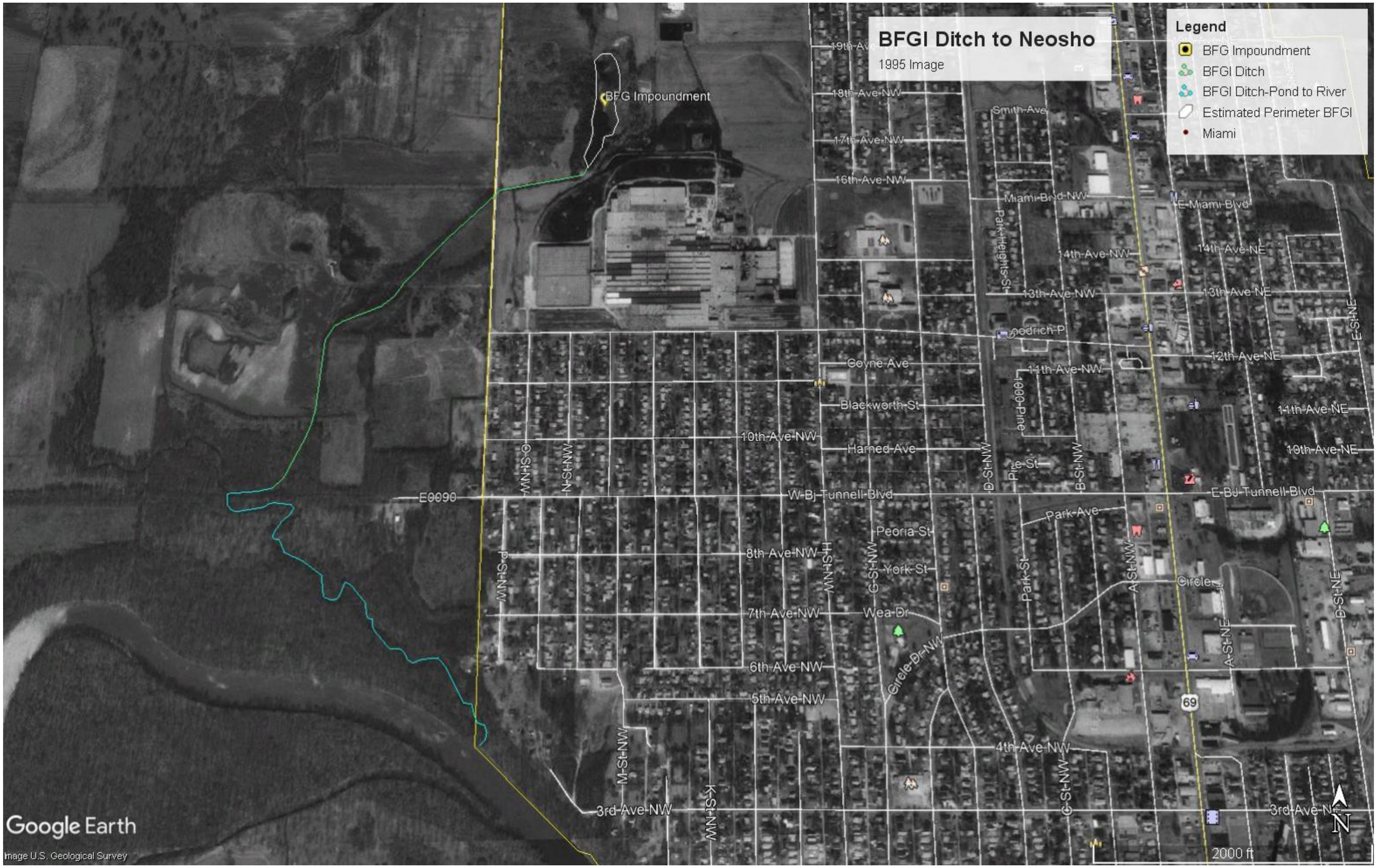


Figure 2A. BFG Impoundment and path of water from Impoundment to Neosho River – 1995 Image

Figure 3A

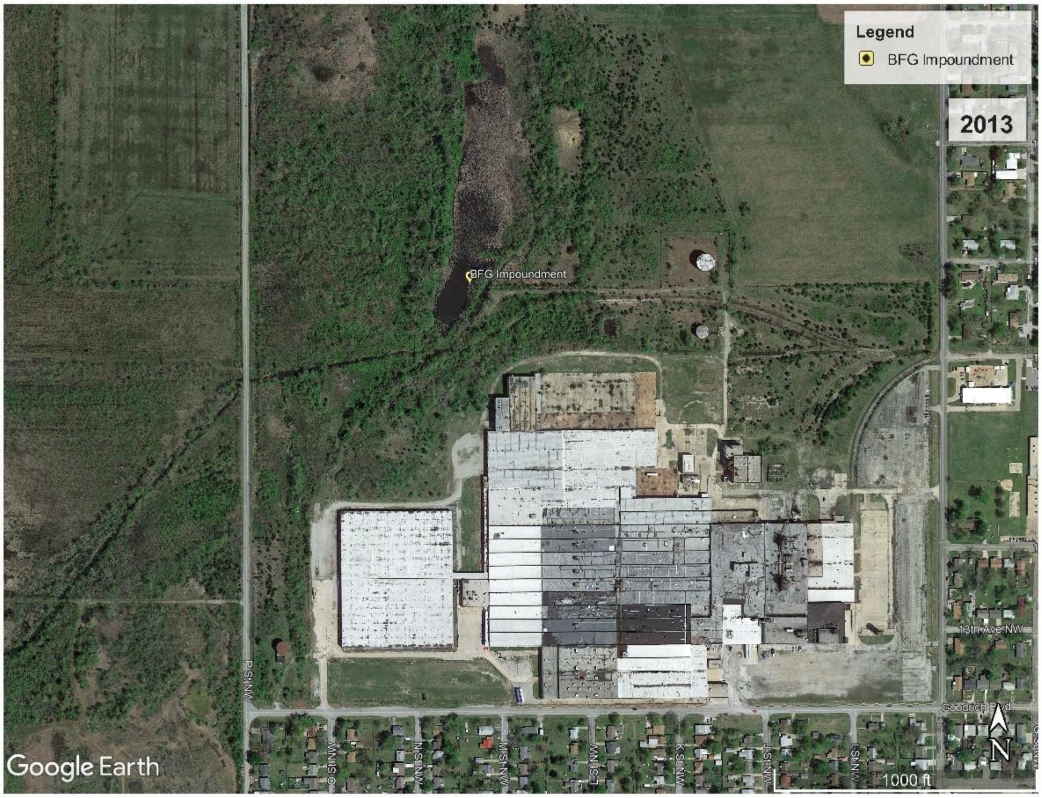


Figure 3B

Figure 3C

Figure 3D

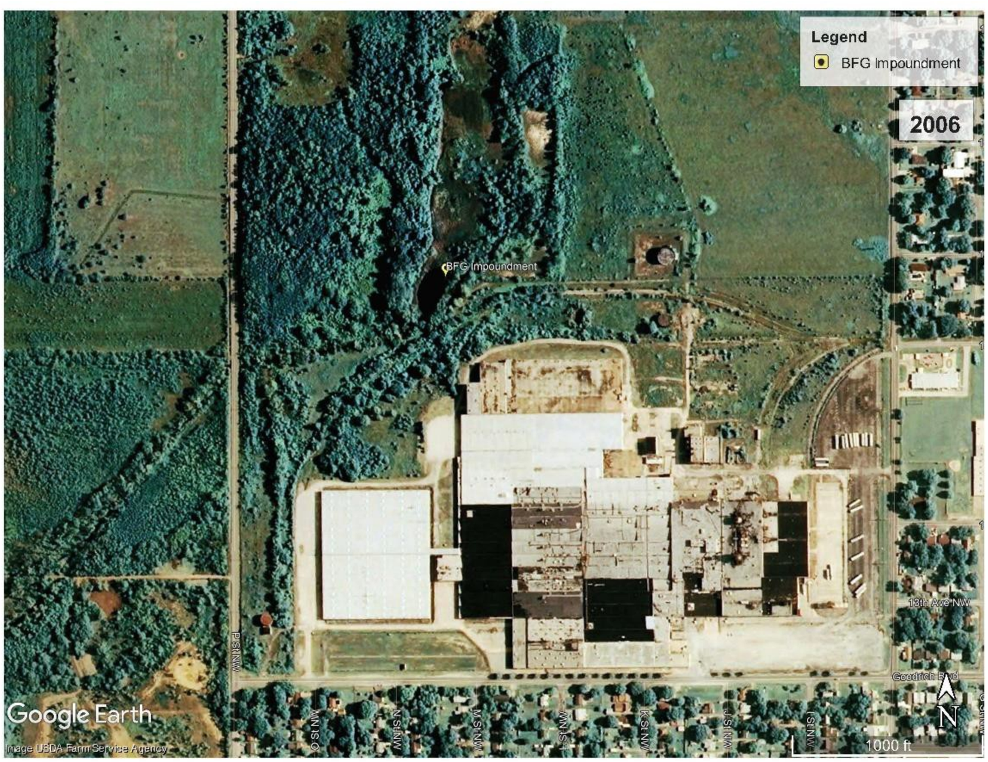


Figure 3E

Figure 3F

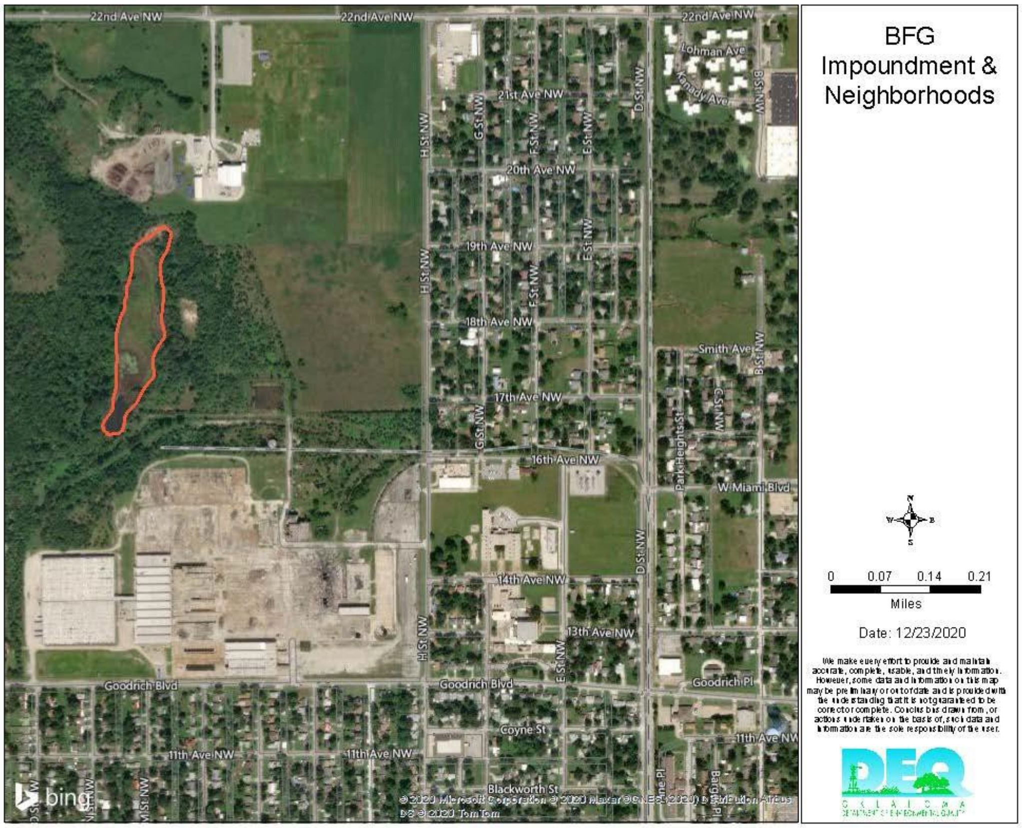


Figure 4A

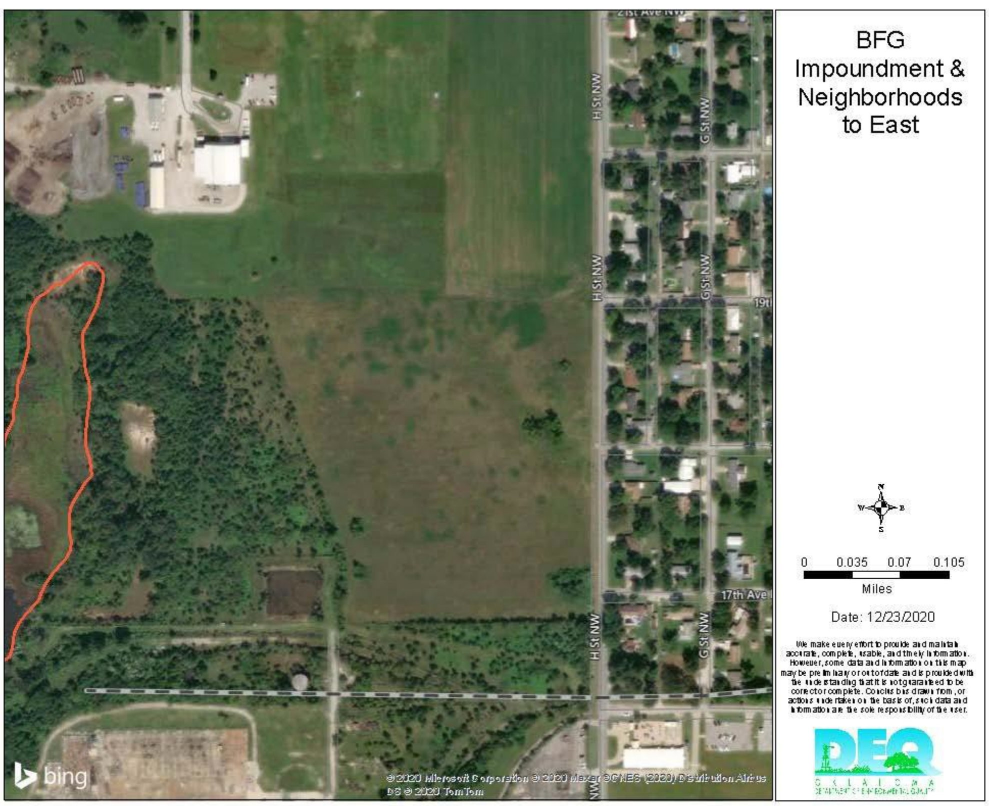
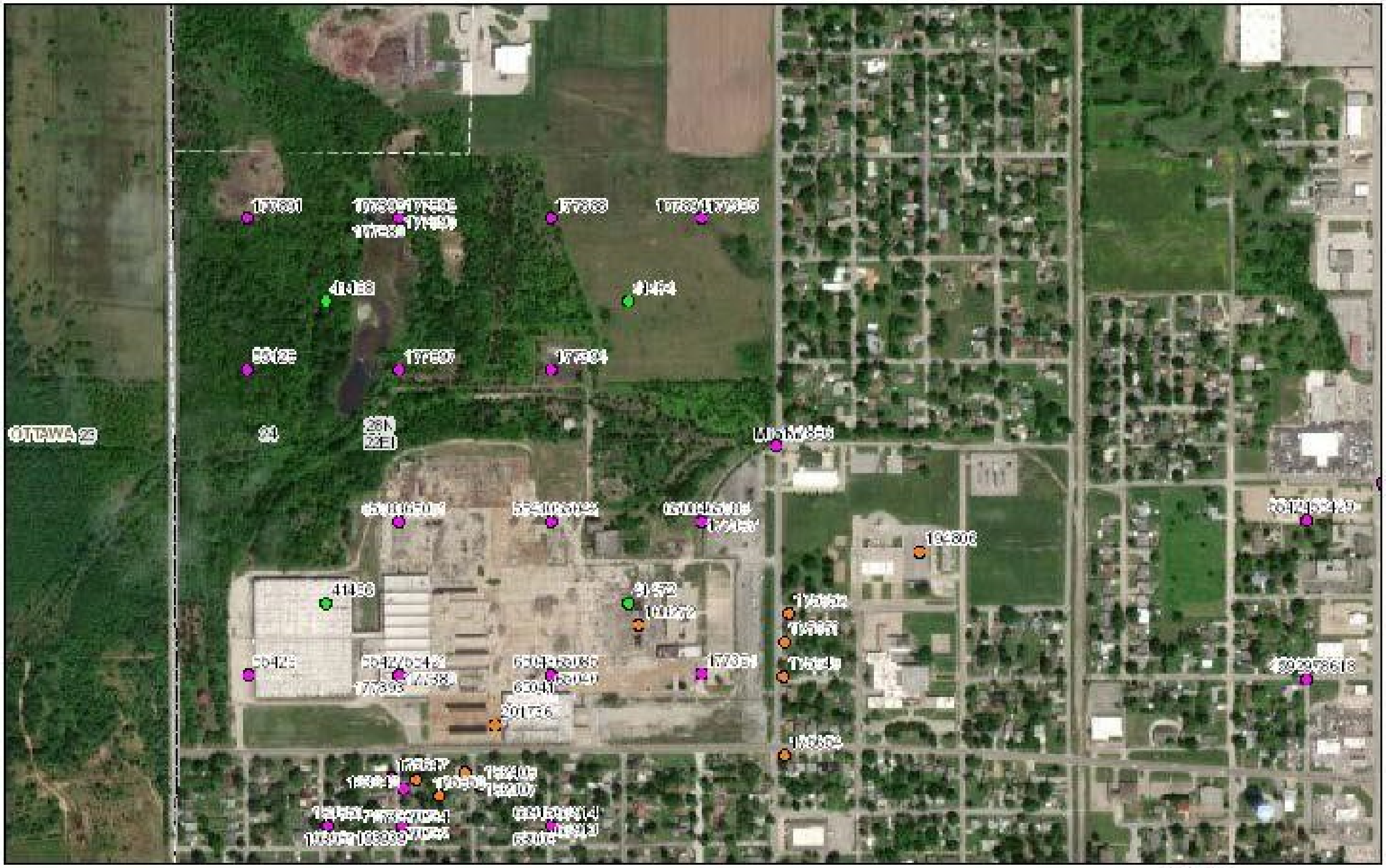


Figure 4A

BFGI wells with #s



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Reported Well Logs · Groundwater Wells · County Boundaries

Other Wells · Sections · State Boundary

Monitoring Wells · Townships · Municipal Boundaries

1:9,028

0 0.05 0.1 0.2 mi

0 0.07 0.15 0.3 km

USDA FSA, GeoEye, Maxar, OWRB, Esri, HERE, Garmin, IPC

ArcGIS Web AppBuilder

OWRB | USDA FSA, Maxar | Esri, HERE, Garmin, IPC |

Figure 5

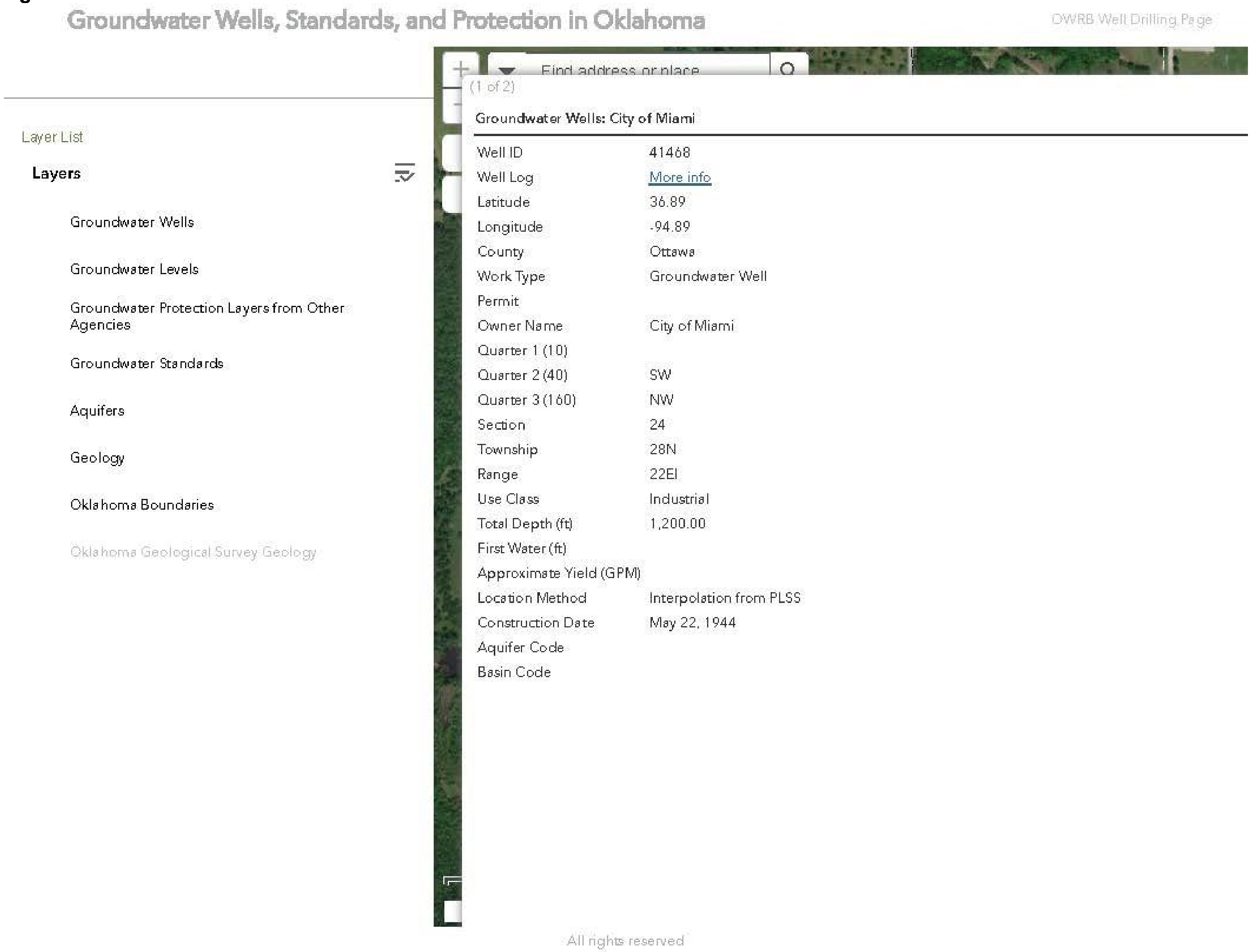

Groundwater Wells, Standards, and Protection in Oklahoma
OWRB Well Drilling Page
Find address or place
(1 of 2)
Layer List
Layers
Groundwater Wells
Groundwater Levels
Groundwater Protection Layers from Other Agencies
Groundwater Standards
Aquifers
Geology
Oklahoma Boundaries
Oklahoma Geological Survey Geology
Groundwater Wells: City of Miami
Well ID 41468
Well Log More info
Latitude 36.89
Longitude -94.89
County Ottawa
Work Type Groundwater Well
Permit
Owner Name City of Miami
Quarter 1 (10)
Quarter 2 (40) SW
Quarter 3 (160) NW
Section 24
Township 28N
Range 22EI
Use Class Industrial
Total Depth (ft) 1,200.00
First Water (ft)
Approximate Yield (GPM)
Location Method Interpolation from PLSS
Construction Date May 22, 1944
Aquifer Code
Basin Code
All rights reserved

Figure 6

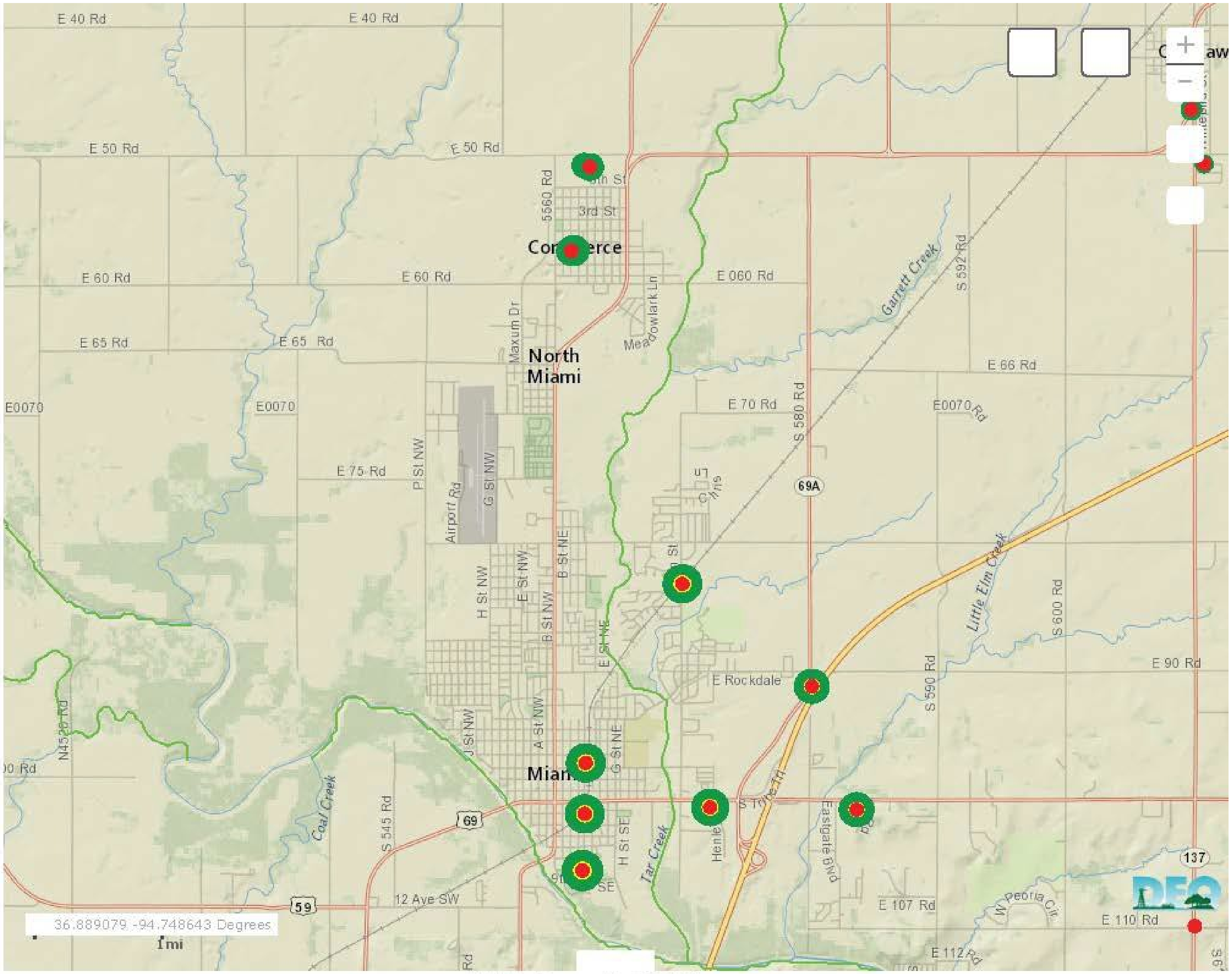
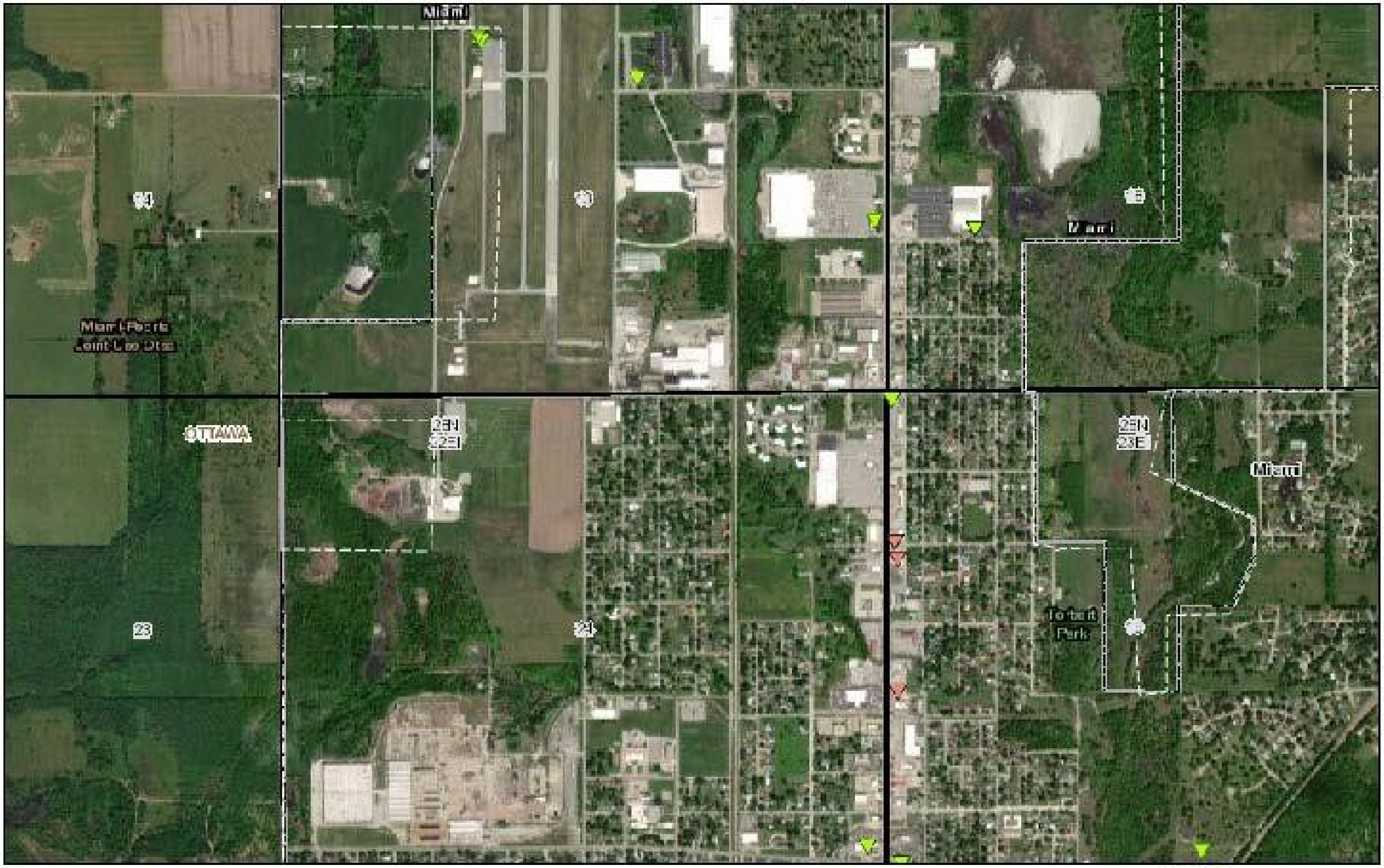


Figure 7, City of Miami Public Water Supply Wells and Wellhead Protection Areas.

BFG Area UST



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Regulated Underground Storage Tanks (OCC)

Yes

No

Sections

Townships

County Boundaries

State Boundary

Municipal Boundaries

1:18,056

0 0.13 0.25 0.5 mi

0 0.17 0.35 0.7 km

USDA FSA, GeoEye, Maxar, Esri, HERE, Garmin, IPC

ArcGIS Web AppBuilder

OWRB | USDA FSA, Maxar | Esri, HERE, Garmin, IPC |

Figure 8

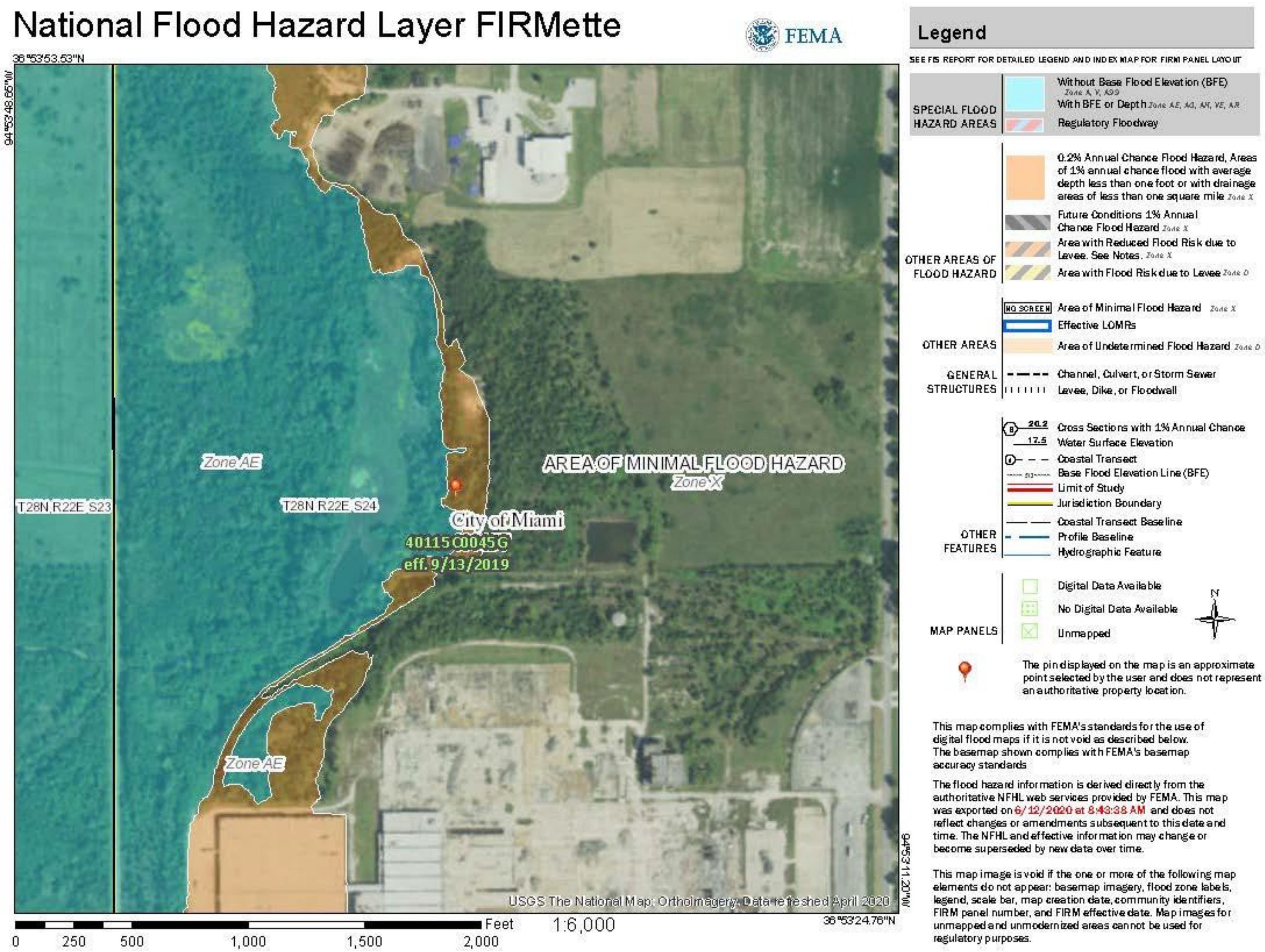
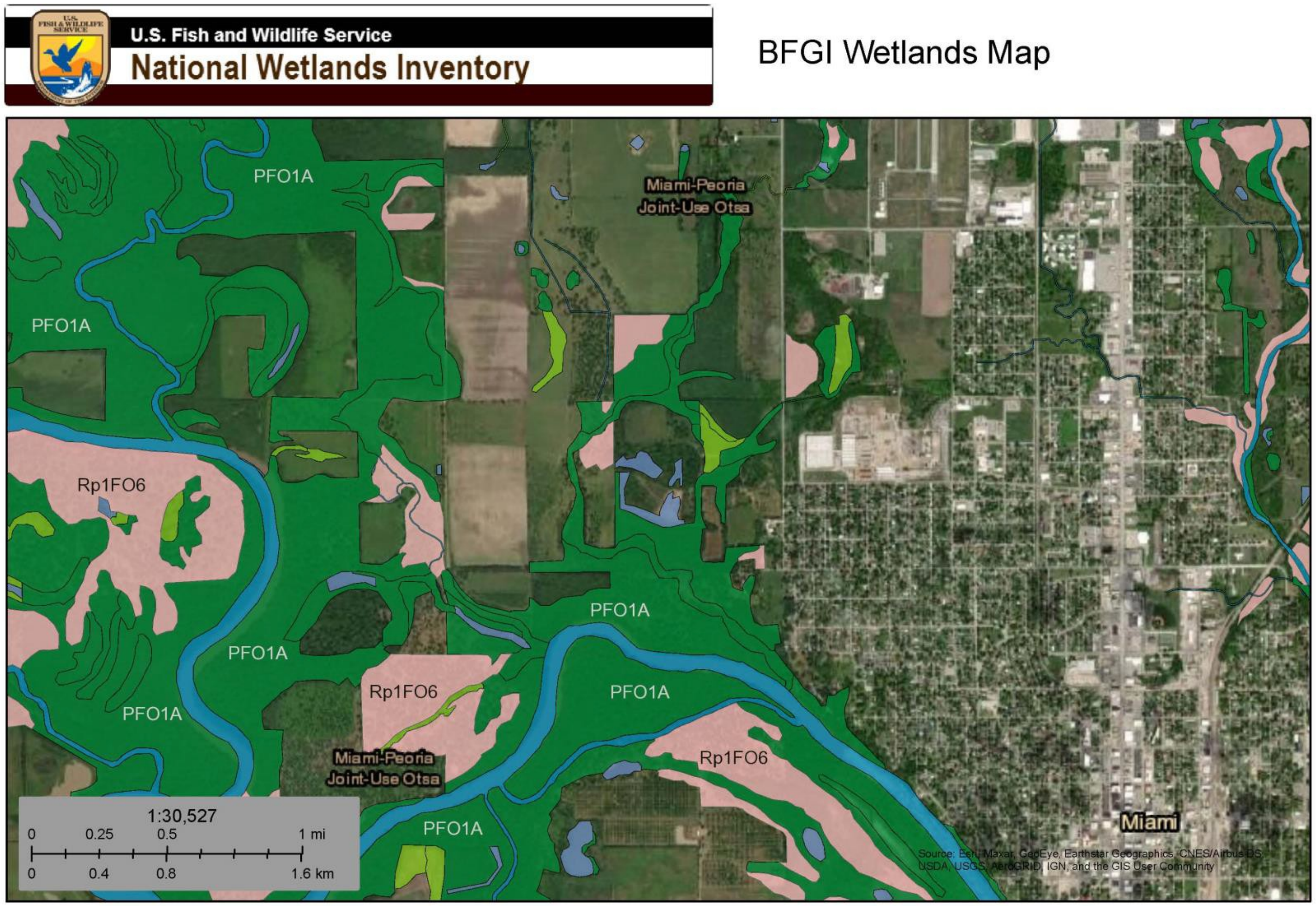


Figure 9A



June 15, 2020

Wetlands

- Estuarine and Marine Deepwater
- Estuarine and Marine Wetland
- Freshwater Emergent Wetland
- Freshwater Forested/Shrub Wetland
- Freshwater Pond
- Lake
- Other
- Riverine

This map is for general reference only. The US Fish and Wildlife Service is not responsible for the accuracy or currentness of the base data shown on this map. All wetlands related data should be used in accordance with the layer metadata found on the Wetlands Mapper web site.

National Wetlands Inventory (NWI)
This page was produced by the NWI mapper

Figure 9B

BFG Area Wetlands

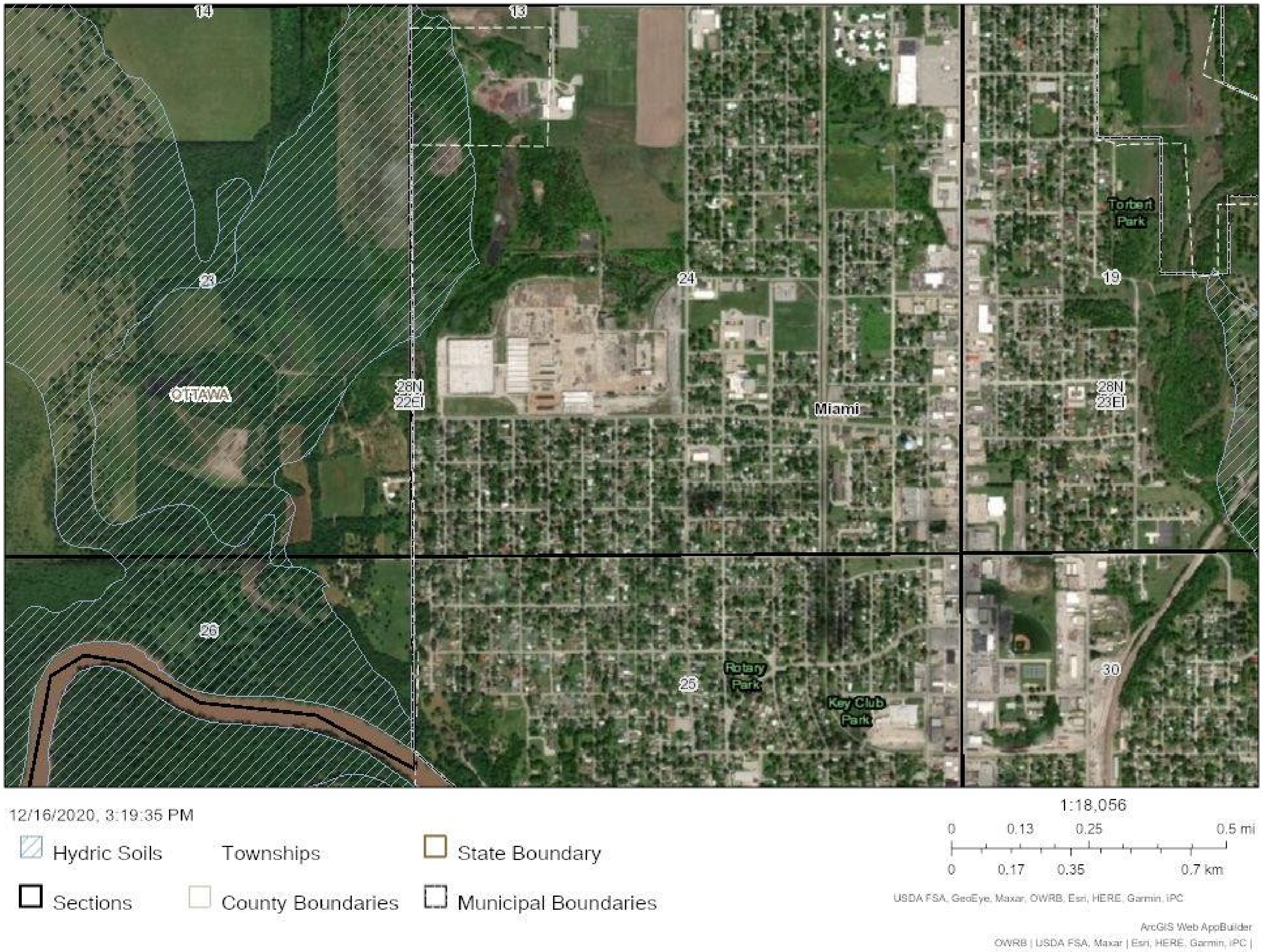


Figure 9C

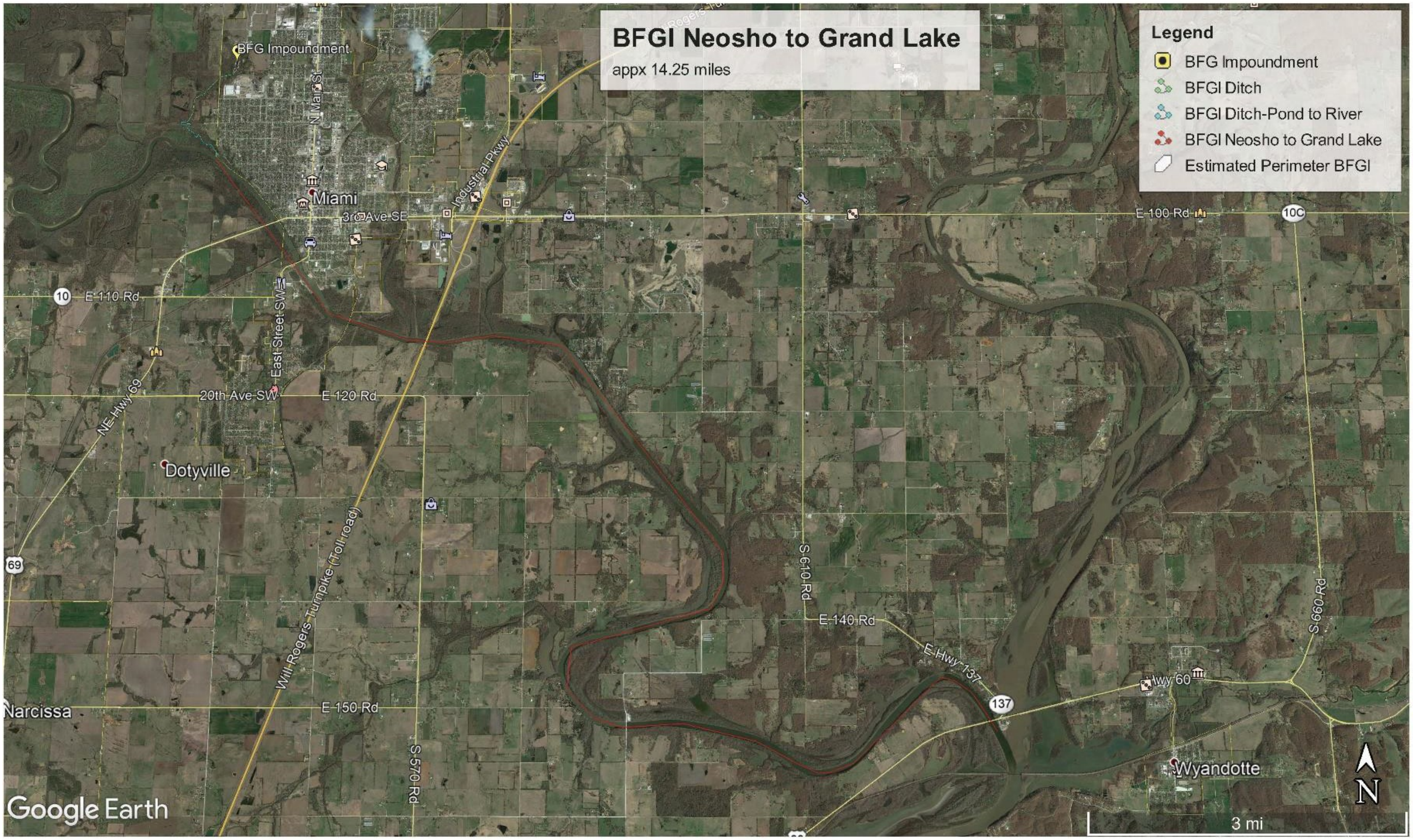


Figure 10, Neosho River from Miami to Grand Lake O' the Cherokees

VIII. Photographs

Note – All photos were taken from P Street, December 17, 2020

Impoundment Drainage Ditch from P Street – Looking East

Impoundment Drainage Ditch from P Street – Looking East # 2

Photo 2

IX. References List

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IARC Working Group on the Evaluation of Carcinogenic Risks to Humans. Chemical Agents and Related Occupations. Lyon (FR): International Agency for Research on Cancer; 2012. (IARC Monographs on the Evaluation of Carcinogenic Risks to Humans, No. 100F.)

OCCUPATIONAL EXPOSURES IN THE RUBBER-MANUFACTURING INDUSTRY

Occupational exposures in the rubber-manufacturing industry were considered by previous IARC Working Groups in 1981 and 1987 (IARC, 1982, 1987). Since that time new data have become available, which have been incorporated in this *Monograph,* and taken into consideration in the present evaluation.

1. Exposure Data

In the context of this *Monograph*, the rubber industry is restricted to the rubber-manufacturing industry, including the production of tyres and general rubber goods and the process of re-treading. The production of synthetic polymers in chemical plants is not discussed.

1.1. Manufacturing process

Rubber manufacturing generally comprises the following operations: raw materials handling, weighing and mixing; milling; extruding and calendering; component assembly and building; ‘curing’ or vulcanizing; inspection and finishing; storage and dispatch. A detailed description of these steps in the production process can be found in IARC (1982).

Although the stages described below are applicable to the majority of rubber goods manufactured from solid polymer, a substantial proportion of rubber production involves the use of liquid latex. This applies to the manufacture of dipped rubber goods (such as rubber gloves and some footwear), foam-latex products (such as mattresses, cushions, etc.), and extruded thread products (such as elasticated fabrics and surgical hose).

1.1.1. Raw materials handling, weighing and mixing

All the materials required for the manufacture of the finished product are assembled. The raw polymer, either natural or synthetic is brought together at this stage with a variety of compounding chemical additives before being introduced into a mixer. The extensive range of chemicals required and the volume of raw material handled can give rise to substantial quantities of airborne dust.

1.1.2. Milling

From the mixer, the uncured rubber compound usually passes to one or more milling machines, where it is thoroughly blended to ensure an even dispersion of its chemical constituents. At this stage, considerable heat is generated, and, although many technical improvements have been introduced in recent years, the job of mill operator still involves a considerable degree of physical exertion and exposure to fumes arising from the heated compound.

1.1.3. Extruding and calendering

The extruders force the rubber compound through a die into various forms, which are then cut to appropriate lengths. Strips of softened rubber compound are fed into multiple-roll milling machines (calenders) to form rubber sheeting, or to apply the rubber directly onto woven textile fabric, which can then be wound off onto a roll. During such manufacturing operations, fumes are often generated.

1.1.4. Component assembly and building

At this stage, solvents are frequently used, with the possibility of inhalation of solvent vapours or of direct effects of the solvent on the skin of the operator.

1.1.5. Curing or vulcanizing

Heat is applied to the product, usually by use of steam, in a curing mould, press, or autoclave. Operators working in the area are exposed both to heat from the presses and to fumes from the heated rubber products. Chemical reactions take place throughout the manufacturing process, and may give rise to new, more volatile chemicals.

1.1.6. Inspection and finishing

This involves the handling of cured rubber products, often while still hot. It usually involves direct and extensive skin-contact with the surface of the finished article (during inspection) and may also involve exposure to vulcanizing fumes. Grinding, trimming, repair, painting and cleaning may also entail exposure to rubber dust, fumes and solvents.

1.1.7. Storage and dispatch

Large quantities of stored rubber goods may release considerable amounts of toxic substances, either as vapours or as constituents of the 'bloom' on the surface of finished goods.

1.2. Chemicals used in the rubber-production process

A wide variety of natural or synthetic elastomers, fillers (e.g. carbon black, precipitated silica or silicates) and additives are used in compounding to create the necessary properties of the final rubber product. The actual chemicals used in this process have changed over time and vary extensively depending on the manufacturing sector (e.g. tyres, general rubber goods, re-treading), and on the specific plant.

Compounding ingredients are classified as vulcanising agents (e.g. elemental sulfur, sulfur donors such as organic disulphides and higher sulphides, peroxides, urethane cross-linking agents); vulcanization accelerators (e.g. sulphenamides, thiazoles, guanidines, thiurams, dithiocarbamates, dithiophosphates, and miscellaneous accelerators such as zinc isopropyl xanthate and ethylene thiourea); vulcanization activators (e.g. zinc oxide, magnesium oxide, lead oxide); retarders and inhibitors of vulcanization (e.g. benzoic acid, salicylic acid, phthalic anhydride, *N*-nitrosodiphenylamine (NDPA), *N*-(cyclohexylthio)phthalimide); antidegradants; antioxidants (e.g. phenolics, phosphites, thioesters, amines, bound antioxidants such as quinone-diimines, miscellaneous antioxidants such as zinc and nickel salts of dithiocarbamates); antiozonants (e.g. *para*-phenylenediamines, triazine derivatives, waxes); anti-reversion agents (e.g. zinc carboxylates, thiophosphoryl derivatives, silane coupling agents, sulphenimide accelerator, hexamethylene-1,6-bis thiosulphate disodium dehydrate, and 1,3-bis(citranimidomethyl)benzene); plasticisers and softeners (e.g. petroleum products such as petroleum waxes and mineral oils, coal-tar products such as coumarone resin, pine products, synthetic softeners, and other products such as vegetable oils and fats); and miscellaneous ingredients (such as peptising agents, blowing agents, bonding agents, and pigments) (Datta & Ingham, 2001).

1.3. Human exposure

Workers in the rubber-manufacturing industry are exposed to dusts and fumes from the rubber-making and vulcanization processes. Potential exposures include *N*-nitrosamines, polycyclic aromatic hydrocarbons, solvents, and phthalates. Inhalation is the main route of exposure, although workers may have dermal exposure as well (e.g. to cyclohexane-soluble compounds). Details on historical occupational exposures in the rubber-manufacturing industry can be found in the previous *IARC Monograph* (IARC, 1982).

Data from studies published since the previous evaluation (IARC, 1982) are summarized below. These are mainly from Europe and North America. Hardly any current exposure data from Asia, where production of rubber goods has increased considerably during the last two decades, was available to the Working Group.

Several industry-wide surveys have been carried out in the United Kingdom (Dost *et al*., 2000) and in the Netherlands (Kromhout *et al*., 1994; Vermeulen *et al*., 2000). In these studies, inhalable dust concentrations, curing-fume concentrations and solvents were measured. A recent European Concerted Action created a large exposure database for the rubber-manufacturing industry in five countries (the United Kingdom, Germany, the Netherlands, Poland, and Sweden). The Improved Exposure Assessment for Prospective Cohort Studies and Exposure Control in the Rubber-Manufacturing Industry (EXASRUB) database contains results of 59609 measurements collected from 523 surveys in 333 factories between 1956 and 2003. The database consists primarily of measurements of *N*-nitrosamines (n = 21202), rubber dust (n = 13655), solvents (n = 8615) and rubber fumes (n = 5932) (de Vocht *et al*., 2005). The long time-span and the presence of longitudinal data from several countries provide insight into long-term temporal trends in exposure concentrations in the rubber-manufacturing industry.

1.3.1. Dust from rubber processing

An industry-wide survey in the Netherlands in 1998 showed geometric mean concentrations of inhalable dust that varied from 0.8 to 1.9 mg/m^3 and from 0.2 to 2.0 mg/m^3 when analysed by plant and by department, respectively. Actual inhalable dust concentrations depended to a large extent on specific conditions within the departments of the 10 plants involved in the study (Kromhout *et al*., 1994). Comparison of the exposure levels nine years later revealed a reduction rate of 5.7% per annum for exposure to inhalable particulate matter. On average, median inhalable dust concentrations went down from 1.00 mg/m^3 to 0.59 mg/m^3 between 1988 and 1997. The steepest decline was observed in companies and departments with the highest exposure levels in 1988 and in workers with long employment. However, the highest concentrations were still seen in the compounding and mixing departments (Vermeulen *et al*., 2000).

Dost et al. (2000) reported on exposure data collected in an industry-wide inventory in the United Kingdom during 1995–97 from 29 re-treading plants, 52 producers of general rubber goods, and seven producers of new tyres. The results show similar patterns at somewhat elevated levels.

These findings were confirmed in an analysis of dust-exposure data (13380 inhalable and 816 respirable dust measurements collected between 1969 and 2003) in the EXASRUB database. Geometric mean inhalable dust concentrations changed by −4% (range −5.8 to +2.9%) per year. Significant reductions were found in all five participating countries for ‘handling of crude materials and mixing and milling’ (−7% to −4% per year) and for ‘miscellaneous workers’ (−11% to −5% per year). Average geometric mean personal exposure levels ranged from 0.72 mg/m^3 in the Netherlands to 1.97 mg/m^3 in Germany. Up to 4–5-fold differences were observed between the countries in the early eighties, but these differences diminished considerably in the two decades afterwards. In most countries, personal measurements appeared to be on average 2–4 times higher than stationary measurements (de Vocht *et al*., 2008).

1.3.2. Fumes from rubber curing

Heating and curing of rubber compounds generates a visible fume. This fume has a complex chemical composition, which makes detailed analysis rather difficult. The cyclohexane-soluble fraction (CSF) of total particulate matter has been used as an indicator of fume contamination in the areas in which the samples were taken. Such monitoring studies are reviewed below.

In the 1988 Dutch industry-wide survey, Kromhout *et al.* (1994) reported a geometric mean CSF concentration of 0.39 mg/m^3 (n = 163) in the curing departments of 10 factories. Considerable variation was seen between the companies, with a range of geometric mean concentrations of 0.21–1.16 mg/m^3.

Median exposures reported for the United Kingdom industry-wide study were highest in the general rubber goods companies at 0.40 mg/m^3, intermediate for re-treading plants at 0.32 mg/m^3 and lowest for manufacturers of new tyres at 0.22 mg/m^3. Process-specific CSF concentrations in rubber goods production were as follows: 0.40 mg/m^3 in moulding, 0.33 mg/m^3 in extrusion, 0.18 mg/m^3 in milling. For re-treading, levels were 0.32 mg/m^3 for pressing, 0.19 mg/m^3 for extruding and 0.10 mg/m^3 for autoclaving (Dost *et al.*, 2000).

Analysis of 5657 CSF measurements in the EXASRUB database collected between 1977 and 2003 showed an annual decrease in concentration of 3% (range −8.6% to 0%). Steepest declines were seen in curing (−8.6% per year) and maintenance and engineering departments (−5.4% per year) (de Vocht *et al.*, 2008).

1.3.3. N-nitrosamines

Nitrosamines in the rubber-manufacturing industry are formed in the vulcanising process, with its extensive use of chemicals such as tetramethyl thiuram disulfide, zinc-diethyldithiocarbamate and morpholinomercaptobenzothiazole.

Exposures to volatile nitrosamines were measured at 24 French rubber-manufacturing plants from 1992 to 1995. A total of 709 exposure measurements (109 in the personal breathing zone, and 600 area samples) were collected. The following five different nitrosamines were identified: *N*-nitrosodimethylamine (NDMA), *N*-nitrosodiethylamine (NDEA), *N*-nitrosodibutylamine, *N*-nitrosopiperidine, and *N*-nitrosomorpholine (NMor). Eighty samples, in which the concentrations were either zero or not quantifiable were excluded. NDMA was the most frequently encountered nitrosamine (detected in 98% of the remaining 629 samples) and represented the most important fraction of the total nitrosamine concentration. For all nitrosamines present, 141 of the concentrations measured exceeded 2.5 µg/m^3. The salt-bath curing process generated particularly high nitrosamine levels, with 90% of the 96 measurements showing concentrations higher than 2.5 µg/m^3, many values even exceeding 20 µg/m^3 (Oury *et al.*, 1997).

Time trends of personal exposure to NDMA and to NMor over two decades (1980–2000) in the German rubber-manufacturing industry were analysed and compared with exposures observed in the Netherlands, Poland, Sweden, and the United Kingdom over the same time period. A total of 2319 NDMA and 2316 NMor measurements contained in the EXASRUB database were analysed. Results from Germany accounted for 88% and 85% of the data for these two amines, respectively. For both NDMA and NMor, the average geometric mean concentration in Germany was 0.13 µg/m^3. Geometric mean concentrations of NDMA ranged from 0.05 µg/m^3 in the Netherlands to 0.34 µg/m^3 in Sweden, while those of NMor ranged from 0.03 µg/m^3 in the United Kingdom to 0.17 µg/m^3 in Poland and Sweden. Exposure to NDMA and NMor decreased on average 2–5-fold in the German rubber-manufacturing industry over this time period, mainly due to the introduction of modern curing systems. Comparable levels were observed in the other European countries (de Vocht *et al.*, 2007).

In a study from Italy, personal exposures to nine airborne *N*-nitrosamines (NDMA, NDEA, *N*-nitrosodi-*n*-propylamine, *N*-nitrosodiisopropylamine, *N*-nitrosodi-n-butylamine, N-nitrosopiperidine, N-nitrosopyrrolidine, and NMor) were measured in 34 workers from four Italian factories that manufactured rubber drive belts for automobile engines. Airborne levels were very low and, in most cases, below the limit of detection of 0.06 µg/m3 (Iavicoli & Carelli, 2006)

Personal exposures to six nitrosamines (NDMA, NDEA, *N*-nitrosodi-*n*-butylamine, *N*-nitrosomorpholine, *N*-nitrosopiperidine, and *N*-nitrosopyrrolidine) were measured in the rubber-manufacturing industry in Sweden (Jönsson *et al.*, 2009). The exposures ranged from less than the limit of detection to 36 µg/m^3, and differed with the vulcanization method used. Workers involved in salt-bath vulcanizination had the highest level of exposure (median, 4.2 µg/m^3).

Although average levels of *N*-nitrosamines are nowadays well below the current exposure limits, exposure to these chemicals has not been eliminated and incidental high exposures do still occur.

1.3.4. PAHs

In a 1997 cross-sectional study of 116 Dutch male workers in the rubber-manufacturing industry, Peters *et al*. (2008) collected urine samples on weekdays and on Sundays, and determined the concentration of 1-hydroxypyrene. The concentrations were significantly higher in workweek samples compared with those collected on Sunday. However, this increase was not uniform across tasks and only reached statistical significance for the curing department ($P = 0.003$).

1.3.5. Solvents

Kromhout *et al*. (1994) measured exposures to solvents in 10 rubber-manufacturing plants in the Netherlands in the late 1980s. The extent of use of individual solvents varied widely and total solvent concentrations were reported. The quantitative assessment of exposure to solvents was restricted to paraffins (hexane, heptane and octane); aromatic compounds (toluene, xylene, trimethylbenzene, naphthalene and isopropylbenzene); chlorinated hydrocarbons (trichloroethylene and 1,1,1-trichloroethane); ketones, alcohols and esters (methylisobutylketone, 2-ethoxyethanol and isobutylacetate). These were chosen on the basis of information on solvents, cements, and release and bonding agents used in the 10 plants. The geometric mean concentration by plant varied from 0.5–46.9 mg/m^3 and ranged from 0.4–34.6 mg/m^3 by department, with the highest exposures reported in the pre-treating departments.

1.3.6. Phthalates

Two studies reported on exposure to phthalates, which are used as plasticizers in the rubber-manufacturing industry. A total of 386 spot-urine samples were collected from 101 Dutch workers employed in nine different factories, and analysed for the presence of phthalic acid and 2-thiothiazolidine-4-carboxylic acid. Samples were collected on Sunday and during the workweek on Tuesday, Wednesday, and Thursday. Geometric mean concentrations of phthalic acid showed a significant 2-fold increase (paired *t*-test; $P < 0.05$) during the workweek compared with the concentrations measured on Sunday (GM, 83 µg/l), with absolute increases of approximately 70 µg/l. The concentrations did not differ markedly between Tuesday, Wednesday and Thursday (GM, 148 µg/l, 152 µg/l and 164 µg/l, respectively). Increases seemed to be restricted to specific factories and/or departments (e.g. moulding and curing) (Vermeulen *et al*., 2005).

In a pilot biomonitoring study in several industries, Hines *et al*. (2009) reported that workers from a rubber boot manufacturing plant had 3-fold higher geometric mean concentrations of diethylhexyl-phthalate metabolites in post-shift urine than the concentrations measured in the general population.

1.3.7. Dermal exposure

Kromhout *et al*. (1994) and Vermeulen *et al*. (2000) reported on dermal exposures to cyclohexane soluble compounds in the rubber-manufacturing industry in the Netherlands. Dermal CSF levels decreased in a similar pattern as inhalation exposures over a 9-year period (1988–1997).

2. Cancer in Humans

The literature reviewed in previous *IARC Monographs* (IARC, 1982, 1987) provided *sufficient evidence* of a causal association between exposures in the rubber-manufacturing industry and cancer. The recent Working Group decided to review evidence from individual studies that appeared after the earlier evaluation (IARC,

1982) making use of a systematic review by Kogevinas *et al*. (1998). Evidence from meta-analyses published by Stewart *et al*. (1999), Borak *et al*. (2005) and Alder *et al*. (2006) was not considered since these studies combined a variety of exposure circumstances that would tend to dilute any observed effect. The Working Group realized that the complexity of occupational exposure in the rubber-manufacturing industry had so far precluded a clear conclusion about an association between increased cancer mortality and incidence and exposure to particular chemicals (except historically well known associations between 2-naphthylamine and bladder cancer, and benzene and leukaemia). Future studies in the rubber-manufacturing industry may overcome this problem by making use more systematically of the wealth of exposure data available in the industry (de Vocht *et al*., 2005, 2009).

2.1. Cancer of the bladder

In the previous *IARC Monograph* (IARC, 1982) it was concluded that there was *sufficient evidence* of an excess occurrence of urinary bladder cancer in workers in the rubber-manufacturing industry. The first evidence appeared when a substantial excess of bladder cancer was noted among workers in this industry in the United Kingdom (Case *et al*., 1954).

2.1.1. Cohort studies

Among workers in the British rubber-manufacturing industry, the death rate from bladder cancer during 1936–1951 was almost twice that of the general population (Case & Hosker, 1954). Studies in other countries also showed an excess of bladder cancer in workers in this industry, but these studies were based on small numbers.

Kogevinas *et al*. (1998) conducted a systematic review of epidemiological studies on cancer in the rubber-manufacturing industry. This review included cohort and case–control studies published after the previous evaluation (IARC, 1982), which were conducted in facilities that manufactured and repaired tyres, manufactured cables and other rubber goods. The authors found that moderately increased risks for bladder cancer were reported in 6 of 8 cohort studies of workers employed in the rubber-manufacturing industry in different regions of the world. In four studies that reported results by calendar period, the risk was highest among workers employed before 1950 (Delzell & Monson, 1984a, b, 1985a, b; Gustavsson et al., 1986; Negri et al., 1989; Szeszenia-Dabrowska et al., 1991). One of these studies reported potential co-exposure to 2-naphthylamine (Szeszenia-Dabrowska et al., 1991).

Two cohort studies of Polish workers published before 1998 were updated and an excess mortality risk for bladder cancer was reported (see Table 2.1, available at http://monographs.iarc.fr/ENG/Monographs/vol100F/100F-31-Table2.1.pdf). In the most recent follow-up of a cohort of Polish workers involved in the manufacture of rubber footwear, non-statistically significant increased risks for bladder cancer were found among men and women (Szymczak *et al*., 2003). In a cohort study among workers in rubber-tyre manufacture in Poland (Wilczyńska *et al*., 2001), no increased risk for bladder cancer was observed among all workers, but analysis of a subcohort of men involved in mixing and weighing of raw materials, milling, extruding and calendaring, showed a non-significantly increased risk. A job-exposure matrix (JEM) for occupational exposure to aromatic amines was used in the analysis of this cohort (de Vocht *et al*., 2009). This JEM was set-up with data from EXASRUB, which provided estimates of geometric mean concentrations for airborne chemicals in each department in the factory during the study period. Internal analyses showed an increased risk in the highest two quartiles of exposure to aromatic amines.

2.1.2. Synthesis

Studies in the rubber-manufacturing industry with documented exposure to 2-naphthylamine clearly show an increased risk of cancer of the urinary bladder. More recent studies that included workers with no recorded exposure to 2-naphthylamine identified moderately increased risks for bladder cancer. [The Working Group could not rule out that the increased risks in recent studies were attributable to exposure to 2-naphthylamine, or whether other exposures in this industry contributed to this risk.]

2.2. Leukaemia

It was concluded in the previous *IARC Monograph* (IARC, 1982) that there was *sufficient evidence* of an excess occurrence of leukaemia in workers in the rubber-manufacturing industry.

2.2.1. Cohort studies

Kogevinas *et al*. (1998) noted four cohort studies that found moderately increased risks for leukaemia among workers in the rubber-manufacturing industry in the USA (Norseth *et al*., 1983; Delzell & Monson, 1984a, b, in two departments of a rubber plant in Akron, Ohio), in Italy (Bernardinelli *et al*., 1987), and in Germany (Weiland *et al*., 1996), while four studies did not report an excess risk (Gustavsson *et al*., 1986; Negri *et al*., 1989; Sorahan *et al*., 1989; Carlo *et al*., 1993). The magnitude of the risk varied between studies, with the highest risks found in studies conducted in North America. The results supported the conclusion that the excess risk for leukaemia was attributable to exposure to solvents, particularly benzene. The authors indicated that a variety of solvent mixtures, with or without benzene, had been used in rubber cements, glues, binding agents, and release agents.

Cohort studies on leukaemia that were published since the review paper mentioned above (Kogevinas *et al*. (1998) are summarized in Table 2.2 (available at http://monographs.iarc.fr/ENG/Monographs/vol100F/100F-31-Table2.2.pdf). Straif *et al*. (1998) reported an excess risk for leukaemia in a cohort of male workers employed in one of five large plants in Germany that produced tyres or general rubber goods (SMR, 1.5; 95%CI: 1.0–2.1). An increased risk was observed in work area I (Preparation of Materials) where solutions were made up, and in work area II (Technical Rubber Goods). Non-significant excesses were also seen in other areas. Longer duration of employment was associated with increased incidence of leukaemia in work area I, particularly among those workers with 10 or more years of employment (SMR, 3.0; 95%CI: 1.5–5.6).

Li & Yu (2002a) conducted a nested case–control study (7 cases of leukaemia, 28 controls) in a rubber-manufacturing facility, and reported an excess risk for leukaemia in workers of the inner-tube department, but not in other departments of the plant. The odds ratio for leukaemia was 7.81 (95%CI: 0.8–78.8) for one or more years of work in the inner-tube department.

2.2.2. Case–control study

McLean *et al*. (2009) conducted a population-based case–control study in New Zealand, with 225 cases of leukaemia and 471 controls. Full occupational histories were obtained by interview. Among those reporting working as rubber/plastics machine-operators (9 cases, 4 controls), the age-, sex- and smoking-adjusted risk estimate was 3.8 (95%CI: 1.1–13.1). The strongest findings, nonetheless, were for plastics rather than for the rubber-manufacturing industry.

2.2.3. Synthesis

The Working Group concluded that there was an increased risk for leukaemia among workers in the rubber-manufacturing industry. The excess risks may be associated with exposure to solvents, in particular benzene.

2.3. Malignant lymphoma including multiple myeloma and other lymphopoietic cancers

It was concluded in the previous review (IARC, 1982) that there was *limited evidence* of an excess occurrence of lymphoma among rubber-manufacturing workers. Excess occurrence of lymphoma had been noted in workers exposed to solvents in departments like footwear production and tyre manufacture (Veys, 1982).

2.3.1. Cohort studies

Kogevinas *et al*. (1998) reported excess risks for malignant lymphoma, including multiple myeloma, ranging from 1.7 to 3.6 in three cohort studies in the USA (Norseth *et al*., 1983; Delzell & Monson, 1984a, b, in a rubber plant in Akron, Ohio) and Italy (Bernardinelli *et al*., 1987), while there was no excess risk in two other cohort studies, in Italy and the United Kingdom (Negri *et al*., 1989; Sorahan *et al*., 1989). Delzell & Monson (1984b, 1985b) reported excess risks for multiple myeloma in certain departments of a rubber plant in Akron, Ohio, as did Gustavsson *et al*. (1986) in Sweden.

Cohort studies published since 1998 are included in Table 2.2, on-line. In Germany, Mundt *et al.* (1999) observed an increased risk for lymphatic system cancers among women employed in one of five large plants that produced tyres or general rubber goods. All cases were seen among women hired after 1950. In the United Kingdom, an increased mortality risk for multiple myeloma was found among men and women in 41 British rubber factories that manufactured tyres and general rubber goods (Dost *et al*., 2007). Women also had increased multiple-myeloma incidence (SRR, 8.1; 95%CI: 1.7–23.7). Excess mortality was observed among workers in the general rubber sector (seven deaths observed, one expected).

Wilczyńska *et al*. (2001). did not find an overall increase in mortality risk for cancers of lymphatic and haematopoietic tissues in a rubber-tyre plant in Poland.

2.3.2. Synthesis

The Working Group concluded that there is *limited evidence* of excess malignant lymphoma among workers in the rubber-manufacturing industry.

2.4. Cancer of the lung

In the previous *IARC Monograph* (IARC, 1982) it was concluded that there was suggestive evidence of an excess incidence of lung cancer among rubber-manufacturing workers, but that the evidence for a causal association with occupational exposures was *limited*.

2.4.1. Cohort studies

Kogevinas *et al*. (1998) noted that the more recently reviewed studies tended to confirm a moderate excess risk for lung cancer. Positive findings were reported in five cohort studies (Delzell & Monson, 1985a, in the curing department; Gustavsson *et al*., 1986; Zhang *et al*., 1989; Szeszenia-Dabrowska *et al*., 1991; Solionova & Smulevich, 1993). These risks were found among workers in tyre-curing departments, mixing and milling, in vulcanization workers, and in a study on jobs with high exposure to fumes or solvents. In three studies excess risks up to 1.5 were reported (Delzell & Monson, 1984b, in the aerospace-product department; Sorahan *et al*., 1989; Weiland *et al*., 1996), while in five cohort studies excess risks were not found (Norseth *et al*., 1983; Delzell & Monson, 1984a, 1985b, in industrial-products and reclaim departments; Bernardinelli *et al*., 1987; Negri *et al*., 1989; Carlo *et al*., 1993).

Cohort studies on lung cancer published after the above-mentioned review (Kogevinas *et al*., 1998) are listed in Table 2.3 (available at http://monographs.iarc.fr/ENG/Monographs/vol100F/100F-31-Table2.3.pdf). In most studies moderate but consistent increases in risk for lung cancer were found; two studies reported no increase in risk (Dost *et al*., 2007; deVocht *et al*., 2009).

From a study of a cohort of German women employed in rubber-manufacturing plants, Mundt *et al.* (1999) reported an increased risk for lung cancer mortality. Stronger associations were observed for certain periods of employment. Among a cohort of German men, a significantly increased risk for lung cancer mortality was observed (Straif *et al*., 2000a). Using internal comparisons, the authors showed increased risks among those employed during one year or more in work areas that involved preparation of materials, technical rubber goods and tyre production (Straif *et al*., 1999). Through retrospective, semiquantitative estimates of exposures to nitrosamines, asbestos and talc, an increased risk for lung cancer in association with high exposure levels for asbestos was observed. An exposure characterization in which categories of medium and high exposure levels of talc were combined with medium exposure to asbestos revealed an exposure-response relationship with lung-cancer incidence (Straif *et al*., 2000a).

Szymczak *et al*. (2003) reported excess lung-cancer mortality among men and women employed in a rubber-footwear plant in Poland. There were increased risks by duration of employment, but no trend was observed. A population-based cohort study of non-smoking women in China also showed an increased risk for lung cancer, after controlling for exposure to secondhand smoke, education level and family history of lung cancer (Pronk *et al*., 2009).

2.4.2. Case–control studies

The findings of population-based case–control studies are listed in Table 2.4 (available at http://monographs.iarc.fr/ENG/Monographs/vol100F/100F-31-Table2.4.pdf). Most notably, in two large multicentre studies of non-smokers, increased risks for lung cancer were found among women who reported having been employed in the rubber-manufacturing industry (Pohlabeln *et al*., 2000; Zeka *et al*., 2006).

2.4.3. Synthesis

Overall, the cohort studies suggest an increased lung-cancer risk among workers in the rubber-maufacturing industry. This conclusion is supported by the findings of population-based case–control studies. The Working Group concluded that there is evidence of excess lung cancer among workers in the rubber-manufacturing industry.

2.5. Cancer of the larynx

In a previous *IARC Monograph* (IARC, 1987) it was indicated that cancer of the larynx had been reported as occurring in excess in workers in the rubber-manufacturing industry, but this excess was not consistent.

2.5.1. Cohort studies

In his review, Kogevinas *et al*. (1998) reported a small but consistent excess risk for laryngeal cancer in seven cohorts, but indicated that the available evidence did not permit an evaluation to be made of the specific agents that may be associated with the increased risk for this cancer.

Straif *et al*. (2000a) found increased mortality from laryngeal cancer among workers in the German rubber-manufacturing industry (see Table 2.3, on-line). The authors indicated that the excess risk may be associated with employment in weighing and mixing and with exposure to asbestos, talc or carbon black. Dost *et al*. (2007) did not find an increased risk for laryngeal cancer mortality and incidence among workers in the British rubber-manufacturing industry. De Vocht *et al*. (2009) did not find increased mortality from laryngeal cancer in a plant that manufactured rubber tyres. They also did not find an association with exposure to aromatic amines or inhalable aerosol.

2.5.2. Synthesis

The Working Group concluded that there was inconsistent evidence of excess laryngeal cancer among workers in the rubber-manufacturing industry. [Tobacco smoking is a risk factor for laryngeal cancer, yet in many studies no adjustment for smoking status was made.]

2.6. Cancer of the stomach

In the previous *IARC Monograph* (IARC, 1982) it was concluded that there was *sufficient evidence* of an excess of stomach cancer among workers in the rubber-manufacturing industry, and limited evidence of a causal association with occupational exposures.

2.6.1. Cohort studies

The conclusions of the previous Working Group (IARC, 1982) were supported by cohort studies of male workers in specific rubber factories. A study in a rubber plant in Akron, Ohio (USA) showed an excess of stomach cancer primarily among workers involved in jobs early in the production line, where exposures are mainly to particulate matter, but also to some fume from uncured rubber (Delzell & Monson, 1982). A case–control analysis of stomach cancer among male workers in the same plant showed a positive association with work early in the production line and with jobs in curing and maintenance (McMichael *et al*., 1976). Further analysis, according to estimated exposure to specific agents, showed a positive association with exposure to talc (Blum *et al*., 1979). In one study in the United Kingdom, mortality from stomach cancer was increased among all workers, but particularly among men in jobs early in the production process (Parkes *et al*., 1982). In a second study in the United Kingdom, excess mortality from stomach cancer was also observed among all workers, but not among particular occupations (Baxter & Werner, 1980).

Kogevinas *et al*. (1998) reported low excess risks for stomach cancer in seven cohort studies. The risk was elevated mainly in mixing and milling departments in two studies (Wang *et al*., 1984; Gustavsson *et al*., 1986) and in jobs with high exposure to dust in a third study (Sorahan *et al*., 1989). Kogevinas *et al*. (1998) indicated that cohort studies published after 1982 either did not confirm the presence of an excess risk or suggested the presence of only a slightly elevated risk.

Cohort studies on stomach cancer published since the above-mentioned review are listed in Table 2.5 (available at http://monographs.iarc.fr/ENG/Monographs/vol100F/100F-31-Table2.5.pdf). In case–cohort study in China of workers in a rubber-manufacturing plant, Li & Yu (2002b) reported an increased risk for stomach cancer. Increased risks were also reported by duration of work in inner tyre-tube manufacturing and milling departments. Mundt *et al*. (1999) found excess risks for stomach cancer among German women employed in the rubber-manufacturing industry, which was stronger among workers hired after 1960.

Straif *et al*. (2000a) reported a moderately increased risk for stomach cancer among male workers in the German rubber-manufacturing industry. An exposure-effect association with talc was observed, but no association with nitrosamines. Data appeared to indicate an association with carbon black, but after adjustment for talc- and asbestos-containing dusts, the risk estimate was lower and no longer significant.

On the basis of internal comparisons, Neves *et al*. (2006) found an increasing risk for stomach cancer among workers in the rubber-manufacturing industry employed in small companies in comparison with workers at large companies, with 10-year lagging and control for confounding (RR, 3.47; 95%CI: 2.57–4.67). Company size was used as a surrogate of probability of exposure to carcinogenic substances. De Vocht *et al*. (2009) found a moderate excess risk for stomach cancer, particularly among workers in the maintenance department of a tyre-manufacturing plant, while Dost *et al*. (2007) showed a modest excess of stomach-cancer incidence among male workers in a study of British rubber plants.

2.6.2. Synthesis

The Working Group concluded that there was evidence of an excess of stomach cancer among rubber-manufacturing workers.

2.7. Cancer of the oesophagus

The previous *IARC Monograph* (IARC, 1982) determined that there was *inadequate evidence* for excess occurrence of cancer of the oesophagus among workers in the rubber-manufacturing industry.

2.7.1. Cohort studies

Kogevinas *et al*. (1998) reported an increased risk for oesophageal cancer in four cohorts (Delzell & Monson, 1985b, in reclaim-department workers; Sorahan *et al*., 1989; Szeszenia-Dabrowska *et al*., 1991, Weiland *et al*., 1996). Other cohorts studies showed no effect.

Straif *et al*. (2000b) reported a significantly increasing trend for oesophageal cancer with increasing exposure to nitrosamines (see Table 2.5, on-line). Tests for trend and associations were also significant for cancers of the lip and oral cavity. In Poland, Szymczak *et al*. (2003) reported a significant excess risk among rubber-footwear workers.

2.7.2. Synthesis

The Working Group concluded that there was some evidence for an excess risk for cancer of the oesophagus among workers in the rubber-manufacturing industry. [The Working Group noted that in none of the studies adjustments were made for tobacco or alcohol use.]

2.8. Cancer of the prostate

The previous *IARC Monograph* (IARC, 1982) concluded that the evidence of excess risk for prostate cancer was *limited* and that the evidence for a causal association with occupational exposures was inadequate.

2.8.1. Cohort studies

Kogevinas *et al*. (1998) reported excess risks for prostate cancer in five studies (Norseth *et al*., 1983; Delzell & Monson 1984a, in the industrial-products department; Bernardinelli *et al*., 1987; Solionova & Smulevich, 1993; Weiland *et al*., 1996). Other studies did not report any excess (Delzell & Monson, 1984b, 1985b; in the aerospace-products and re-claim departments; Gustavsson *et al*., 1986; Sorahan *et al*., 1989; Szeszenia-Dabrowska *et al*., 1991).

Since then, only one case–cohort study that investigated the association between prostate cancer and work in the rubber-manufacturing industry has been published (Zeegers *et al*., 2004). In this study a non-statistically significant increased risk for prostate cancer was found.

2.8.2. Synthesis

The Working Group concluded that there is weak evidence of excess risk for prostate cancer among workers in the rubber-manufacturing industry.

2.9. Other cancers

The previous *IARC Monograph* (IARC, 1982) determined that for cancers of the brain, thyroid and pancreas, the evidence was *inadequate* for an excess in occurrence of these cancers and for a causal association with occupational exposures.

2.9.1. Cohort studies

Kogevinas *et al*. (1998) reported that findings for other cancer sites were not consistent between studies, or were derived from too few studies. Since this review, studies on workers in the rubber-manufacturing industry with excess cancers of the brain, pancreas, gallbladder, cervix and liver have been reported (see Table 2.6 available at http://monographs.iarc.fr/ENG/Monographs/vol100F/100F-31-Table2.6.pdf).

2.9.2. Synthesis

The Working Group concluded that there is little evidence of excess risks for cancers at sites other than those mentioned above, being associated with work in the rubber-manufacturing industry. [Excess risks found in single studies may be related to specific exposure circumstances occurring in particular rubber-manufacturing plants. One problem in evaluating findings for other cancer sites is that reporting may have been incomplete in cohort and case–control studies, with possibly preferential reporting of positive findings.]

3. Cancer in Experimental Animals

No data were available to the Working Group.

4. Other Relevant Data

The rubber-manufacturing industry has used and still uses a wide variety of substances that belong to many different chemical categories, e.g. carbon black, aromatic amines, PAH, *N*-nitrosamines, mineral oils, other volatile organic compounds from curing fumes, trace amounts of monomers from synthetic rubber like 1,3-butadiene, acetonitrile, styrene, vinyl chloride, ethylene oxide, etc. (See Section 1). For this reason, it has been difficult to relate the observed cancer hazards in the rubber-manufacturing industry to exposure to specific chemicals.

Table 4.1 presents a list of bio-monitoring studies and cytogenetic assays among workers in the rubber-manufacturing industry in various countries and at different times. These studies have focused on analysis of chromosomal aberrations, sister-chromatid exchange, micronucleus formation, premature chromosome condensation, DNA breakage, DNA-adduct formation, mutagenicity in urine, and mutation in the *HPRT* gene. For each of these endpoints, in most studies a positive response has been observed in exposed workers compared with non-exposed controls. It is noted that the studies listed in Table 4.1 span a period of approximately 25 years.

The multiple genetic and cytogenetic effects observed among workers employed in the rubber-manufacturing industry provide strong evidence to support genotoxicity as one mechanism for the observed increase in cancer risk. However, due to the complexity and changing nature of the exposure mixture and the potential interactions between exposures in this industry, other mechanisms are also likely to play a role.

While it is clear that exposures to some agents in the rubber-manufacturing industry have been reduced over time, the outcome of recent cytogenetic studies continues to raise concerns about cancer risks.

5. Evaluation

There is *sufficient evidence* in humans for the carcinogenicity of occupational exposures in the rubber-manufacturing industry. Occupational exposures in the rubber-manufacturing industry cause leukaemia, lymphoma, and cancers of the urinary bladder, lung, and stomach.

Also, a positive association has been observed between occupational exposures in the rubber-manufacturing industry and cancers of the prostate, oesophagus, and larynx.

No data in experimental animals with relevance to the rubber-manufacturing industry were available to the Working Group.

The multiple genetic and cytogenetic effects observed among workers employed in the rubber-manufacturing industry provide strong evidence to support genotoxicity as one mechanism for the observed increase in cancer risks. However, due to the complexity and changing nature of the exposure mixture and the potential interactions between exposures in the rubber-manufacturing industry, other mechanisms are also likely to play a role. While it is clear that exposure to some agents in the rubber-manufacturing industry has been reduced over time, the results of recent cytogenetic studies continue to raise concerns about cancer risks.

Occupational exposures in the rubber-manufacturing industry are *carcinogenic to humans (Group 1)*.

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Tables

Table 4.1Biomonitoring studies and cytogenetic assays among workers in the rubber-manufacturing industry

Reference	Description of exposed and controls	Exposure levels	Cytogenetic/genotoxic end-point	Response in exposed	Response in controls	Comments
Degrassi *et al.* (1984) Italy	Exposed: Vulcanizers ($n = 34$) in a rubber plant Controls: Workers ($n = 16$) in the same plant and living in the same geographic area	Airborne particulate matter ranged from 0.5 to 3.4, with an average (± SD) of 1.1 (± 1.1) mg/m^3. Exposure duration (± SE) was 8.2 ± 0.8 yr	Chromosomal aberrations (per 100 cells)	1.9 ± 1.4 (excl. gaps)	2.1 ± 1.5 (excl gaps)	NS
			SCE (per cell)	5.2 ± 1.3	5.2 ± 0.7	Cigarette smoking was associated with increased SCE in exposed and controls. Chromosomal aberrations were not correlated
Hema Prasad *et al.* (1986) India	Exposed: Workers ($n = 35$) employed for 3–12 yr in a rubber factory. There were 20 unexposed controls (not specified)	NR	Chromosomal aberrations (per 100 cells)	Ranged from 1.57 to 2.75, increased with longer time at work	0.6 per 100 cells	$P < 0.05$ No information is given about smoking.
Sasiadek (1992) Poland	Exposed: Vulcanizers (14 women, 7 men; 14 were smokers) in a rubber plant. Controls: Non-exposed women ($n = 7$) and men ($n = 7$), of whom 5 were smokers	Exposure duration was 14.2 ± 9.7 yr (range 2–35 yr)	Chromosomal aberrations (per 100 cells)	2.2 ± 1.06 (incl. gaps)	0.9 ± 1.0 (incl.gaps)	$P < 0.01$
			SCE (per cell)	16.1 ± 3.5	10.0 ± 1.5	$P < 0.001$
Sasiadek (1993) Poland	Exposed: Vulcanizers (19 women, 7 men; 10 were smokers) in a rubber plant. Controls: Non-exposed women ($n = 15$) and men ($n = 10$), of whom 10 were smokers	Exposure duration was 0.5–30 yr (mean 15.6 ± 9.5 yr).	SCE (per cell)	13.2 ± 2.9 (range 9–20)	9.8 ± 1.8 (range 7–14)	$P < 0.001$
Ward *et al.*	Workers in	Exposure	a) *HPRT* mutants,	3.99 ± 2.81 (high) and	1.03 ± 0.12 *HPRT* mut	$P < 0.02$

Reference	Description of exposed and controls	Exposure levels	Cytogenetic/genotoxic end-point	Response in exposed	Response in controls	Comments
(1996) USA	a butadiene-production plant (10 high-exposed, 10 low-exposed) in Texas, USA. Non-exposed controls from elsewhere ($n = 9$). All 29 were non-smokers. Second study: follow-up after 8 mo. Ongoing study among workers in a styrene-butadiene rubber plant in the same area. Data are presented on 16 high-exposed (5 smokers) and 9 low-exposed (3 smokers) subjects	survey by the company: mean level 3.5 ± 7.25 ppm From 8-h personal breathing zone air samples: 0.30 ± 0.59, 0.21 ± 0.21, and 0.12 ± 0.27 ppm for high-, intermediate- and low-exposure areas Passive dosimeters worn during the 8-h shift: of 40 samples, 20 were > 0.25 ppm, 11 were > 1 ppm	lymphocytes b) butadiene metabolite in urine (see comments)	1.20 ± 0.51 (low) *HPRT* mutants/10^{-6} cells	ants per 10^{-6} cells	
				5.33 ± 3.76* (high) 2.27 ± 0.99 (medium), 2.14 ± 0.97 (low) mutants/10^{-6} cells		*$P < 0.02$
				Non-smokers: 7.47 ± 5.69 (high)** 1.68 ± 0.85 (low) *Smokers:* 6.24 ± 4.37 (high)** 3.42 ± 1.57 (low)		** $P < 0.01$ *Comment:* dihydroxybutane mercapturate, 1,2-dihydroxy-4(*N*-acetyl-cysteinyl)butane, was measured in urine by GC/MS. The high-exposure groups (butadiene-monomer plant only) had significantly higher levels.
Moretti *et al.* (1996) Italy	Workers at 4 rubber plants ($n = 19$; 9 smokers) and 20 age-matched (± 5 yr) blood donors as controls (8 of whom were smokers)	NR	a) mutagenicity in urine b) urinary excretion of thioethers	a), b): no differences between exposed and controls		
			c) DNA damage in lymphocytes	median migration distance in Comet assay: 37.99 µm	median migration distance: 33.81 µm	$P > 0.05$
			d) SCE	5.51 ± 0.82 /metaphase	6.06 ± 1.15	$P > 0.05$
			e) MN formation	22.84 ± 15.82 MN per 1000 binucleated cells	13.74 ± 4.42	$P < 0.05$
Major *et al.* (1999) Hungary	Subjects ($n = 29$, among whom 24 were smokers; 23 men, 6 women) with mixed	Exposures included aromatic solvents, dust, tar, lubricating oil. No quantitative data given		*Exposed*	*Industrial controls*	
			a) chromosomal aberrations per 2900 metaphases scored	3.38 ± 0.26	1.60 ± 0.62	$P < 0.01$
			b) PCD: - mitoses with ≤ 3 chromosomes	11.45 ± 1.43	1.57 ± 0.44	$P < 0.01$

Reference	Description of exposed and controls	Exposure levels	Cytogenetic/genotoxic end-point	Response in exposed	Response in controls	Comments
	industrial exposure during 3–20 yr in the rubber-manufacturing industry. Controls were living and/or working in the vicinity of chemical plants, but had no occupational exposure to chemicals (industrial controls)		- mitoses with > 3 chromosomes	6.00 ± 1.18	0.32 ± 0.10	$P < 0.01$
			c) aneuploidy	5.64 ± 0.44	6.20 ± 0.43	NS
Somorovská *et al.* (1999) Slovak Republic	Workers (27 men, 2 women; 18 smokers, 11 non-smokers) in a rubber tyre factory. The industrial controls comprised 22 clerks (8 men, 14 women; 14 smokers, 8 non-smokers) from the same factory. A second control group comprised 17 men and 5 women (7 smokers, 15 non-smokers) who worked in a laboratory in Bratislava	Air sampling was followed by analysis of styrene, toluene, butadiene, PAHs, alkanes, and alkenes	a) DNA breakage (Comet assay) b) chromosomal aberrations c) MN assay	*Sample 1* (1996): 33% DNA in tail *Sample 2* (1997): 45% DNA in tail	*Factory controls:* 13% DNA in tail *Laboratory controls:* 22% DNA in tail	$P < 0.00001$
				1 aberration/100 cells	*Factory controls:* 0.4 aberr./100 cells *Laboratory controls:* 0.2 aberr./100 cells	$P < 0.00001$
				6.5 MN/2000 cells	*Factory controls:* 2.1 MN/2000 cells *Laboratory controls:* 1.5 MN/2000 cells	$P < 0.00001$
Zhu *et al.* (2000) Guangzhou, China	Workers [197 men (130 smokers) and 174 women (6 smokers)] at	Environmental monitoring of dust, toluene, xylene, gasoline, H_2S, SO_2	DNA breakage (Comet assay; results given as tail moment)	*All rubber workers:* 1.77 (1.64–1.90)* µm *Finishing:* 1.81 (1.48–2.21) µm *Calendering:* 1.77 (1.54–2.03) µm *Vulcanizing:*	*Managerial workers:* 1.52 (1.36–1.71) µm	* $P = 0.04$ *Comment*: Non-drinking, non-smoking mixers also had higher tail moment than comparable managers: 2.25 (1.66–3.03) vs 1.39 (1.18–1.63)

Reference	Description of exposed and controls	Exposure levels	Cytogenetic/genotoxic end-point	Response in exposed	Response in controls	Comments
	a factory that produced tyres, pads and other products. Among these, 281 were in rubber-processing jobs, and 90 controls were in management. There were 318 drinkers and 53 non-drinkers			1.64 (1.46–1.83) μm *Mixing:* 2.54 (1.95–3.31)** μm		μm ($P = 0.049$) ** $P = 0.002$
Ma *et al.* (2000) Texas, USA	Male non-smoking workers at a styrene-butadiene polymer plant. Controls were employees at the University of Texas Medical Branch	Breathing-zone air sampling with personal monitors	Analysis of *HPRT* variants and mutants, and of exon deletions in the *HPRT* gene in lymphocytes, with a multiplex PCR assay	*HPRT* variants per 10^{-6} cells: 6.86 ± 3.25 ($n = 12$)	2.36 ± 1.04 ($n = 8$)	$P < 0.05$
				HPRT mutants per 10^{-6} cells: 17.63 ± 5.05 ($n = 10$)	8.47 ± 2.88 ($n = 11$)	$P < 0.05$
Ward *et al.* (2001) Texas, USA (study conducted in 1998)	Workers in a BD rubber plant: 22 in a high-exposure and 15 in a low-exposure group, with levels of 1.71 ± 0.54 (SE) and 0.07 ± 0.03 (SE) ppm butadiene, respectively	Exposure to 1,3-BD was monitored with organic vapour monitors and varied from 4.04 ± 3.45 ppm (tank farm) to 0.29 ± 0.33 (laboratory). Low areas* had 0.05 ± 0.06 ppm *packaging, baling, warehouse, shipping	*HPRT* mutant analysis in lymphocytes	*High-exposure group:* All ($n = 22$)–10.67 ± 1.51 (SE) Non-smokers ($n = 12$)–8.64 ± 1.60 Smokers ($n = 10$)–13.10 ± 2.57	*Low-exposure group:* All ($n = 15$)–3.54 ± 0.61 Non-smokers ($n = 14$)–3.46 ± 0.65 Smokers–4.61	$P = 0.001$ $P = 0.011$ *Comment*: increases in *HPRT* variant frequency of about threefold are seen at average BD exposure levels of 1–3 ppm
Ammenheuser *et al.* (2001) Texas, USA	Workers ($n = 24$) in the reactor, recovery, tank farm and laboratory area of a BD rubber	Workers were asked to wear an organic vapour monitor during one 8-h work-shift, to measure exposure to butadiene/styre	*HPRT* mutant analysis in lymphocytes	*High-exposure group:* Non-smokers ($n = 19$)–6.8 ± 1.2* (SE) Smokers ($n = 5$)–6.1 ± 2.0	*Low-exposure group:* Non-smokers ($n = 20$)–1.8 ± 0.2 Smokers ($n = 5$)–3.3 ± 0.5	* $P < 0.0005$

Reference	Description of exposed and controls	Exposure levels	Cytogenetic/genotoxic end-point	Response in exposed	Response in controls	Comments
	plant represented a high-exposure group. Workers (n = 25) in blending, coagulation, baling, shipping, the control room and utility areas were a low-exposure group	ne. Lower detection limit: 0.25 ppm BD				
Vermeulen *et al*. (2002) the Netherlands	Workers in the rubber-manufacturing industry (n = 52; all non-smokers)	Mutagenicity on likely skin-contact surfaces (high, ≥ 25 revertants/cm^2; low, < 25 rev/cm^2) and in ambient air (high, ≥ 210 rev/m^3 low, < 210 rev/m^3) tested in YG1041 of *S. typhimurium*	DNA-adduct analysis in exfoliated bladder cells collected from 24-h urine, by ^{32}P-postlabelling. Samples from 32 slow and 20 fast acetylators (based on *NAT2* analysis)	Of 52 urine samples, 46 gave reliable data for the presence of three main adducts: 1 in 41 samples, 2 in 13 samples, 3 in 29 samples	NR	The 'slow *NAT2*' subjects had lower levels of adducts 1–3 than the fast acetylators. (P < 0.04; P = 0.32; P = 0.15, resp) No information is given on the identity of the adducts
Laffon *et al.* (2006) Portugal	Exposed male workers (n = 32) and non-exposed male controls (n = 32) in a rubber tyre factory in Oporto, of whom 39% were smokers	NR	a) thio-ethers in post-shift urine	0.41 ± 0.05 mM	0.24 ± 0.02 mM	P < 0.01
			b) microncleus test (MN per 1000 cells)	2.34 ± 0.33	1.84 ± 0.29	NS
			c) SCE/cell	4.35 ± 0.20	4.38 ± 0.17	NS
			d) DNA-breakage (Comet assay) (tail length, µm)	44.72 ± 0.66	48.25 ± 0.71	P < 0.01
Peters *et al.* (2008) the Netherlands	Workers (n = 116; 45 smokers, 71 non-smokers) in the Dutch rubber-manufacturing industry, selected on the basis of their function in the production	NR		*Weekday samples:*	*Sunday samples:*	
			a) Hydroxypyrene in urine (result for non-smokers)	0.15–0.19 µmol/mol creatinine	0.12 µmol/mol creatinine	P < 0.0001
			b) Mutagenic activity in urine (revertants/g creatinine) of workers in compounding and mixing	10 511	6522	P < 0.05
			c) DNA adducts in urothelial cells and	Increased compared with control		

Reference	Description of exposed and controls	Exposure levels	Cytogenetic/genotoxic end-point	Response in exposed	Response in controls	Comments
	process. Urine and blood were collected		in peripheral blood monocytes			
Musak *et al.* (2008) Czech Republic	Workers in a tyre plant (*n* = 177; 69 smokers) and 172 controls (49 smokers)	Personal samplers worn in breathing zone. Average BD level in the mixing department was 2.6 ± 0.2 mg/m^3	Chromosomal aberrations (per 100 metaphases)	2.5 ± 1.8	1.7 ± 1.2	$P = 0.055$
Wickliffe *et al.* (2009) Texas, USA	Workers in a BD rubber plant (see Ward *et al.*, 2001 above)	Current exposures: mean 93.5 ppb, median 2.5 ppb	*HPRT* mutant analysis in lymphocytes	Current, low, exposures to butadiene in this plant do not seem to increase the *HPRT* mutant frequency. However, older workers showed increased *HPRT* mutant frequencies, likely due to previous chronic exposure to higher levels of butadiene.		

BD, styrene-butadiene; h, hour or hours; *HPRT,* hypoxanthine-guanine phosphoribosyltransferase; mo, month or months; MN, micronucleus; NR, not reported; NS, not significant; PCD, premature chromosome condensation; SCE: Sister-chromatid exchange; SD standard deviation; SE standard error; vs, versus; yr, year or years

Bookshelf ID: NBK304412

Reference 2 Climate

OKLAHOMA
CLIMATOLOGICAL SURVEY
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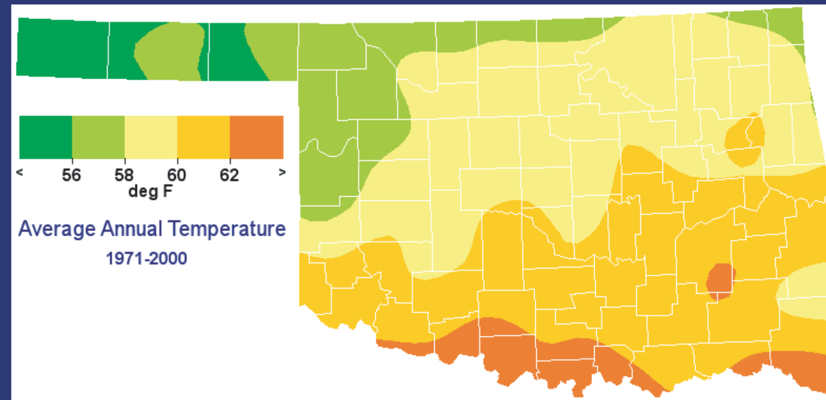
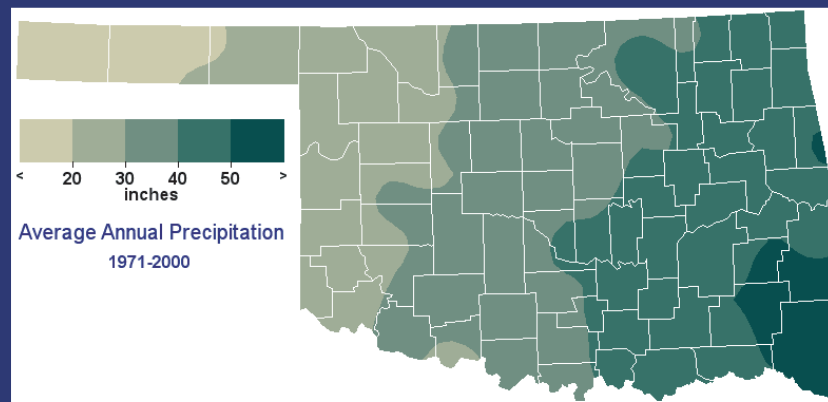




TEMPERATURE

Average Annual: 59 degrees
Average Maximum: 70 degrees
Average Minimum: 47 degrees
Highest: 116 degrees
(Miami, July 14, 1954)
Lowest: -25 degrees
(Miami, January 22, 1930)
Days of 90 Degrees or Higher: 58
Days of 20 Degrees or Lower: 30

PRECIPITATION

Average Annual: 44.85 inches
Days With Precipitation: 87
Wettest Year: 66.90 inches in 1973
Driest Year: 19.89 inches in 1963
Greatest Daily Rainfall: 9.15 inches
(Miami, July 7, 1958)

OTHER FACTS

Average Wind Speed: 8 mph
Sunshine: 50- 75%
Average Humidity: 72%
Thunderstorm Days: 53
Hail Events: 7 per year
Tornadoes (1950-2003): 25

WINTER WEATHER

Average Annual Snowfall: 10.0 inches
Days with snow on ground: 9
Greatest Seasonal Snowfall: 25.2 inches (1923-1924)
Greatest Daily Snowfall: 14.0 inches
(Miami, March 12, 1968)
Last Freeze in Spring: April 9
First Freeze in Autumn: October 27
Growing Season: 200 Days

Ottawa County Climate Summary

Snapshot of State & Climate Division Data
Temperature and Precipitation
State & Climate Divisions Data
December 2015 to November 2020

	Temp	Norm	Dep	Prcp	Norm	Dep	%Norm	
Clim_Div OK01	57.5	56.5	1.0	106.22	102.89	3.33	103	
Clim_Div OK02	59.5	58.5	1.0	167.03	157.12	9.91	106	
Clim_Div OK03	60.0	59.0	1.0	233.86	213.36	20.51	110	
Clim_Div OK04	60.6	59.2	1.3	146.94	142.00	4.94	103	
Clim_Div OK05	61.5	60.2	1.2	201.77	188.17	13.60	107	Miami is in Clim-Div OK05
Clim_Div OK06	61.9	60.5	1.3	257.12	230.72	26.40	111	
Clim_Div OK07	62.6	61.4	1.3	161.30	151.38	9.92	107	
Clim_Div OK08	63.2	62.1	1.1	225.50	203.55	21.95	111	
Clim_Div OK09	62.7	61.0	1.7	284.92	252.98	31.95	113	
Statewide OK	61.0	59.8	1.2	198.26	182.47	15.79	109	

Normals for this product are 1981-2010.

Midwestern Regional Climate Center
cli-MATE: MRCC Application Tools Environment
Generated at: 12/28/2020 10:19:49 AM CST

cli-MATE
MRCC APPLICATION TOOLS ENVIRONMENT

Hi Hal!
Log out

CURRENT STATION INFORMATION:
Station Name: JOPLIN REGIONALAIRPORT
County: JASPER
State: MO

More Info

MRCC Midwestern Regional Climate Center

Privacy Policy

Data Selector

Printer Version

CSV Version

Send Feedback

Monthly Data Summary
JOPLIN REGIONAL AIRPORT (MO)
USW00013987
Total Precipitation (in)

To sort multiple columns, hold SHIFT while clicking on the columns.

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
1991	2.63	0.52	2.02	4.56	2.68	1.43	2.23	2.05	3.76	3.12	3.21	4.82	33.03
1992	0.69	2.95	2.53	4.45	2.77	5.04	12.43	0.80	8.95	2.60	11.56	6.60	61.37
1993	2.52	4.00	3.06	3.80	8.92	8.56	5.40	3.20	14.02	1.98	2.52	1.84	59.82
1994	1.52	2.34	2.24	9.30	2.25	2.37	5.66	2.92	2.63	5.38	10.53	1.43	48.57
1995	3.24	0.57	1.31	8.02	9.37	8.67	2.80	3.28	1.65	0.16	1.00	2.81	42.88
1996	2.26	0.27	2.36	6.19	4.10	4.94	3.17	3.53	6.20	5.27	7.20	0.19	45.68
1997	1.19	4.25	3.49	1.77	6.11	5.21	3.69	4.06	3.59	3.89	3.26	3.69	44.20
1998	3.68	M	M	3.81	3.66	6.94	4.19	2.62	6.00	9.69	3.09	1.20	*44.88
1999	2.35	1.26	3.56	10.38	10.26	9.09	2.45	1.71	2.98	0.85	1.14	7.67	53.70
2000	1.11	1.86	2.93	1.90	5.75	7.54	5.01	0.05	2.72	4.40	2.07	1.28	36.62
2001	3.44	4.66	0.81	2.26	5.76	6.37	3.72	1.48	2.56	6.45	3.99	2.40	43.90
2002	3.09	0.73	2.65	4.10	12.88	4.71	4.88	1.14	1.63	2.30	0.56	2.10	40.77
2003	0.29	2.53	2.96	2.93	4.19	7.01	1.31	3.35	4.00	1.75	2.34	4.19	36.85
2004	2.88	1.01	6.04	7.02	3.56	5.66	6.28	2.04	0.74	5.41	6.56	1.34	48.54
2005	5.09	2.36	1.08	3.12	3.96	3.76	2.12	3.89	3.72	2.17	1.08	0.42	32.77
2006	1.05	0.01	1.57	4.87	7.47	2.48	3.29	2.46	1.16	1.62	3.64	2.80	32.42
2007	2.55	2.08	3.42	4.28	5.11	17.12	0.85	5.32	7.43	3.37	0.70	3.32	55.55
2008	1.07	3.82	7.63	7.42	10.79	9.36	4.86	4.01	7.90	2.90	1.39	2.08	63.23
2009	0.75	2.38	2.35	3.08	4.41	4.72	3.58	6.42	6.91	8.78	0.61	2.03	46.02
2010	1.40	0.88	4.33	1.94	7.56	4.22	7.89	0.89	6.81	1.21	4.43	1.52	43.08
2011	0.16	2.47	5.18	6.37	7.53	1.02	0.83	2.45	3.92	0.67	5.62	2.76	38.98
2012	0.16	2.58	6.29	6.26	4.14	1.26	T	3.13	7.20	4.63	1.31	1.06	38.02
2013	2.45	2.70	2.70	6.65	7.89	5.39	3.31	4.60	0.20	4.75	2.42	1.38	44.44
2014	0.59	0.26	1.88	1.25	4.77	3.93	1.24	1.52	4.53	8.08	1.95	1.84	31.84
2015	0.70	0.82	1.83	3.95	10.41	7.67	5.09	8.23	1.12	0.70	8.11	9.77	58.40
2016	0.30	0.37	2.57	4.55	6.31	6.12	5.30	4.26	2.98	5.25	0.87	0.59	39.47
2017	3.65	0.34	2.70	11.24	8.00	4.18	3.11	5.46	1.49	4.31	0.52	1.37	46.37
2018	0.47	4.94	2.30	2.11	3.53	2.99	2.06	6.62	2.23	2.57	2.02	2.69	34.53
2019	2.72	1.87	2.84	6.55	14.17	8.49	6.27	5.98	4.45	5.19	2.54	1.37	62.44
2020	3.66	2.42	8.04	5.52	8.47	1.63	3.66	2.58	1.19	4.35	3.47	M	*44.99
Count:	30	29	29	30	30	30	30	30	30	30	30	29	
Average:	1.92	1.97	3.20	4.99	6.56	5.60	3.89	3.33	4.16	3.79	3.32	2.64	
Median:	1.89	2.08	2.70	4.50	5.94	5.12	3.62	3.17	3.66	3.63	2.47	2.03	
Low Value:	0.16	0.01	0.81	1.25	2.25	1.02	0.00	0.05	0.20	0.16	0.52	0.19	
High Value:	5.09	4.94	8.04	11.24	14.17	17.12	12.43	8.23	14.02	9.69	11.56	9.77	

M = Missing

T = Trace

* The annual data is incomplete, and not used for the calculation of the summary statistics.

Midwestern Regional Climate Center
cli-MATE: MRCC Application Tools Environment
Generated at: 12/28/2020 10:53:39 AM CST

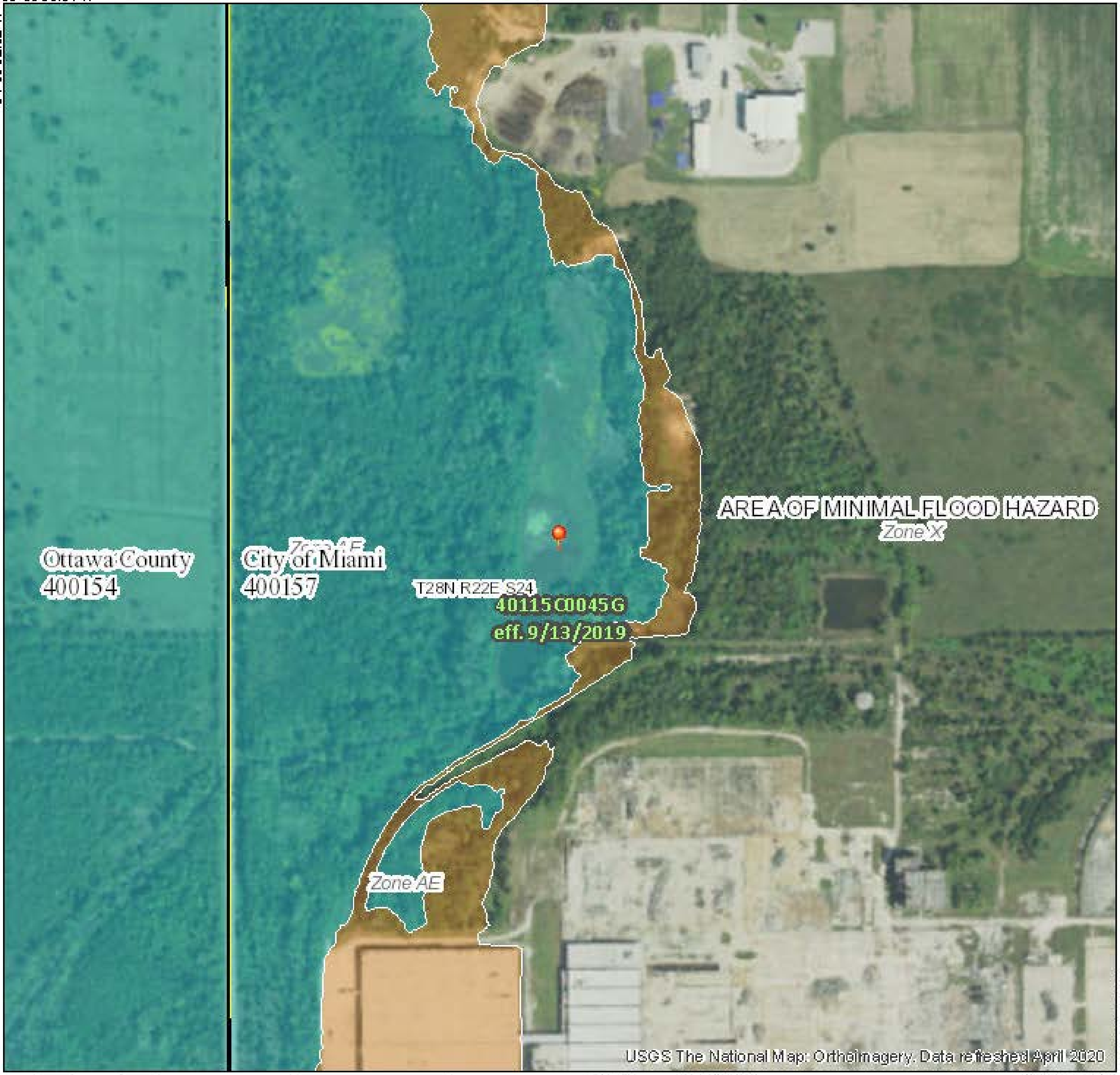
Reference 3 Wetlands

National Flood Hazard Layer FIRMette

FEMA

36°53'53.51"N

94°53'52.02"W



94°53'14.58"W

36°53'24.73"N

Feet 1:6,000

0 250 500 1,000 1,500 2,000

Legend

SEE FIS REPORT FOR DETAILED LEGEND AND INDEX MAP FOR FIRM PANEL LAYOUT

SPECIAL FLOOD HAZARD AREAS
- Without Base Flood Elevation (BFE) *Zone A, V, A99*
- With BFE or Depth *Zone AE, AO, AH, VE, AR*
- Regulatory Floodway

OTHER AREAS OF FLOOD HAZARD
- 0.2% Annual Chance Flood Hazard, Areas of 1% annual chance flood with average depth less than one foot or with drainage areas of less than one square mile *Zone X*
- Future Conditions 1% Annual Chance Flood Hazard *Zone X*
- Area with Reduced Flood Risk due to Levee. See Notes. *Zone X*
- Area with Flood Risk due to Levee *Zone D*

OTHER AREAS
- NO SCREEN Area of Minimal Flood Hazard *Zone X*
- Effective LOMRs
- Area of Undetermined Flood Hazard *Zone D*

GENERAL STRUCTURES
- Channel, Culvert, or Storm Sewer
- Levee, Dike, or Floodwall

OTHER FEATURES
- 20.2 / 17.5 Cross Sections with 1% Annual Chance Water Surface Elevation
- Coastal Transect
- 513 Base Flood Elevation Line (BFE)
- Limit of Study
- Jurisdiction Boundary
- Coastal Transect Baseline
- Profile Baseline
- Hydrographic Feature

MAP PANELS
- Digital Data Available
- No Digital Data Available
- Unmapped

N

The pin displayed on the map is an approximate point selected by the user and does not represent an authoritative property location.

This map complies with FEMA's standards for the use of digital flood maps if it is not void as described below. The basemap shown complies with FEMA's basemap accuracy standards

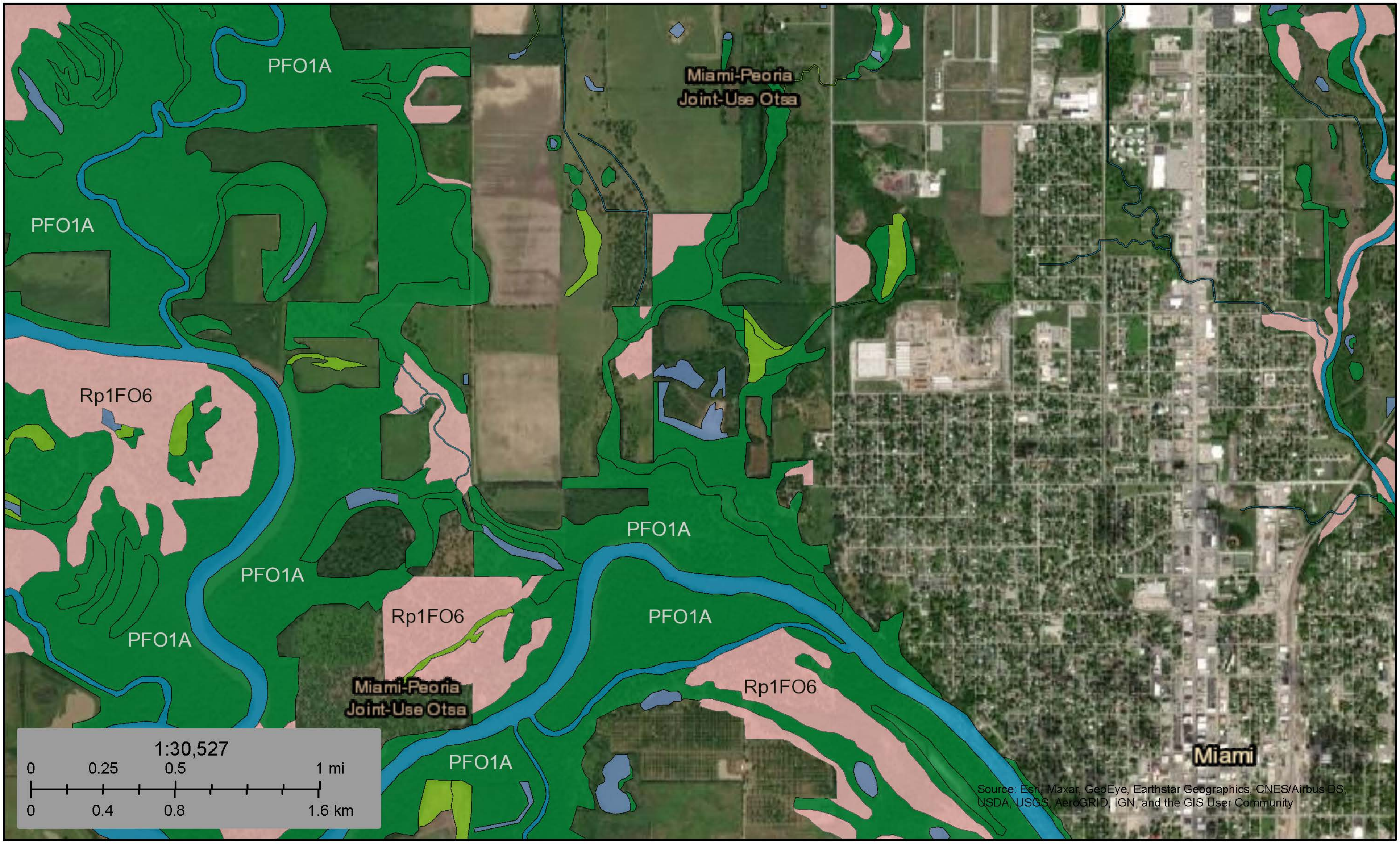
The flood hazard information is derived directly from the authoritative NFHL web services provided by FEMA. This map was exported on 6/12/2020 at 9:08:01 AM and does not reflect changes or amendments subsequent to this date and time. The NFHL and effective information may change or become superseded by new data over time.

This map image is void if the one or more of the following map elements do not appear: basemap imagery, flood zone labels, legend, scale bar, map creation date, community identifiers, FIRM panel number, and FIRM effective date. Map images for unmapped and unmodernized areas cannot be used for regulatory purposes.

U.S. Fish and Wildlife Service

National Wetlands Inventory

BFGI Wetlands Map



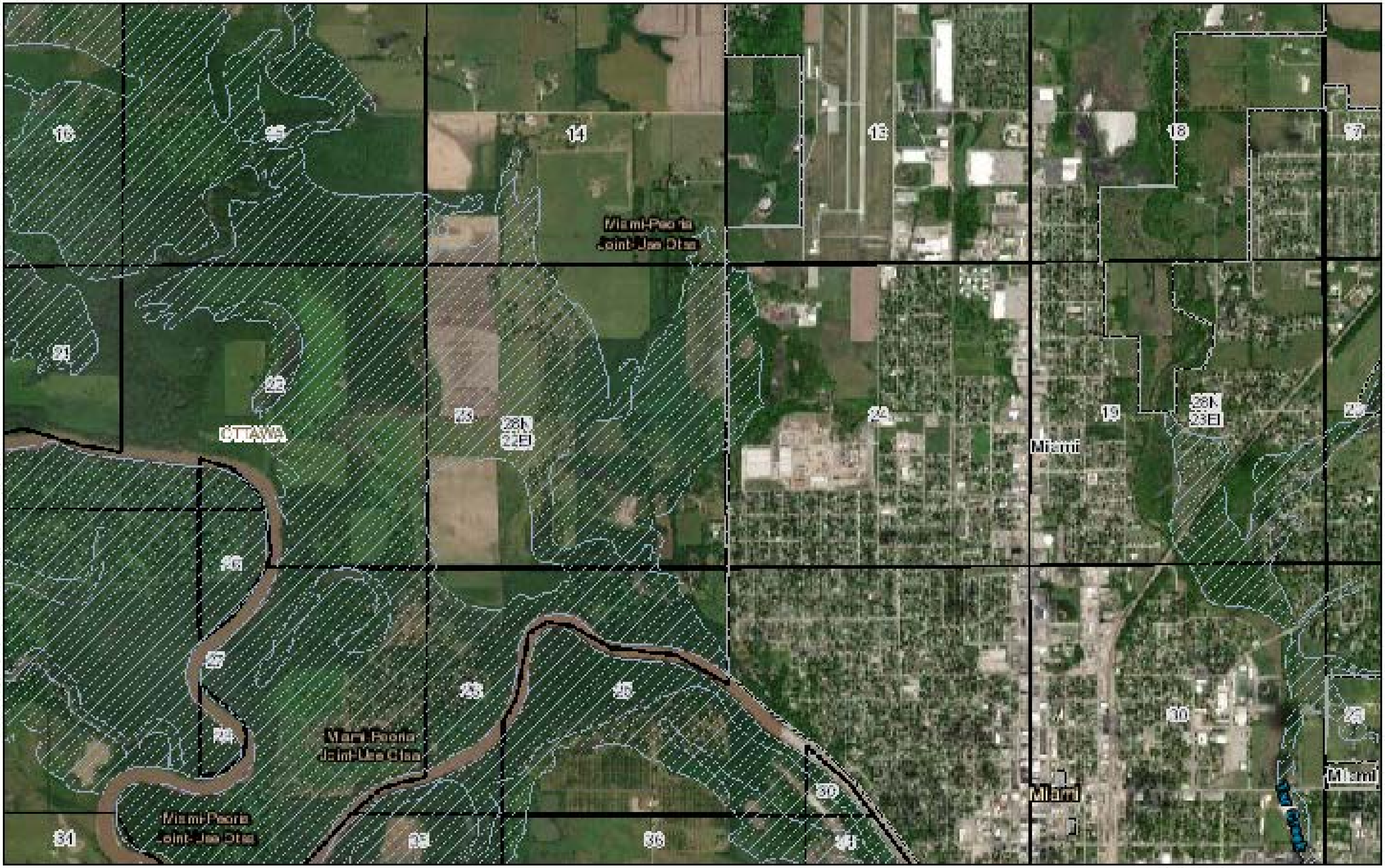
June 15, 2020

Wetlands

- Estuarine and Marine Deepwater
- Estuarine and Marine Wetland
- Freshwater Emergent Wetland
- Freshwater Forested/Shrub Wetland
- Freshwater Pond
- Lake
- Other
- Riverine

This map is for general reference only. The US Fish and Wildlife Service is not responsible for the accuracy or currentness of the base data shown on this map. All wetlands related data should be used in accordance with the layer metadata found on the Wetlands Mapper web site.

BFG Area Wetlands



12/16/2020, 3:17:14 PM

Hydric Soils

Townships

State Boundary

Sections

County Boundaries

Municipal Boundaries

1:36,112

0 0.25 0.5 1 mi

0 0.38 0.75 1.5 km

Esri, HERE, Garmin, USDA FSA, GeoEye, Maxar, OWRB

ArcGIS Web AppBuilder

OWRB | USDA FSA, Maxar | Esri, HERE, Garmin |

Reference 4 Groundwater and Surface Water

MEMORANDUM

DATE: December 29, 2020

TO: BF Goodrich Impoundment PA/SI File

FROM: Hal Cantwell, Environmental Programs Specialist

RE: Water Systems and Groundwater Wells within ¼, ½, 1, 2, 3, and 4-mile radius of the BF Goodrich Impoundment Site, Ottawa County, Miami, Oklahoma

According to the Oklahoma Safe Drinking Water Information System (SDWIS), the public water system of Miami is serviced by nine active public supply wells. The closest two public water supply wells are located 1.83 miles east and 1.72 miles southeast of the Impoundment respectively. The wells reach water at approximately 400 – 500 feet below ground surface. The population served by the public water system is approximately 13,704 residential people and 433 working people. A City of Miami industrial supply well is 0.75 miles northeast of the Impoundment and is the closest groundwater use well to the site.

The table below depicts the number of private groundwater wells within a 4-mile radius of the BF Goodrich Impoundment site. The estimated population served by private wells is calculated by multiplying the number of wells by the average number of persons per household in Miami (2.56).

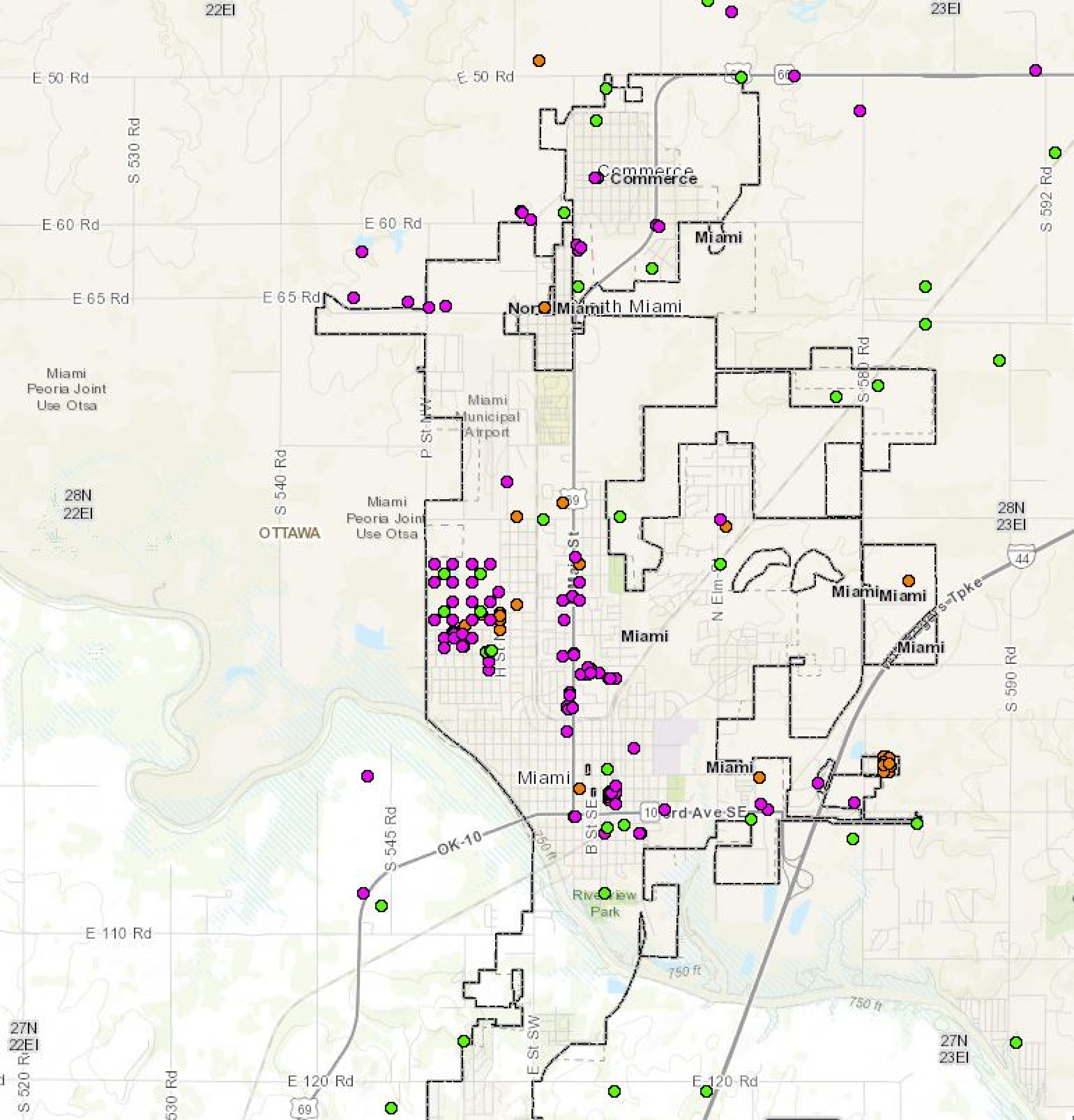
Distance from Site	Number of Wells	Est. Population Served by Private Wells
Onsite	0	0
0 - ¼ mile	0	0
¼ - ½ mile	0	0
½ - 1 mile	0	0
1 - 2 miles	0	0
2 - 3 miles	3	9
3 - 4 miles	4	12
Total	7	21

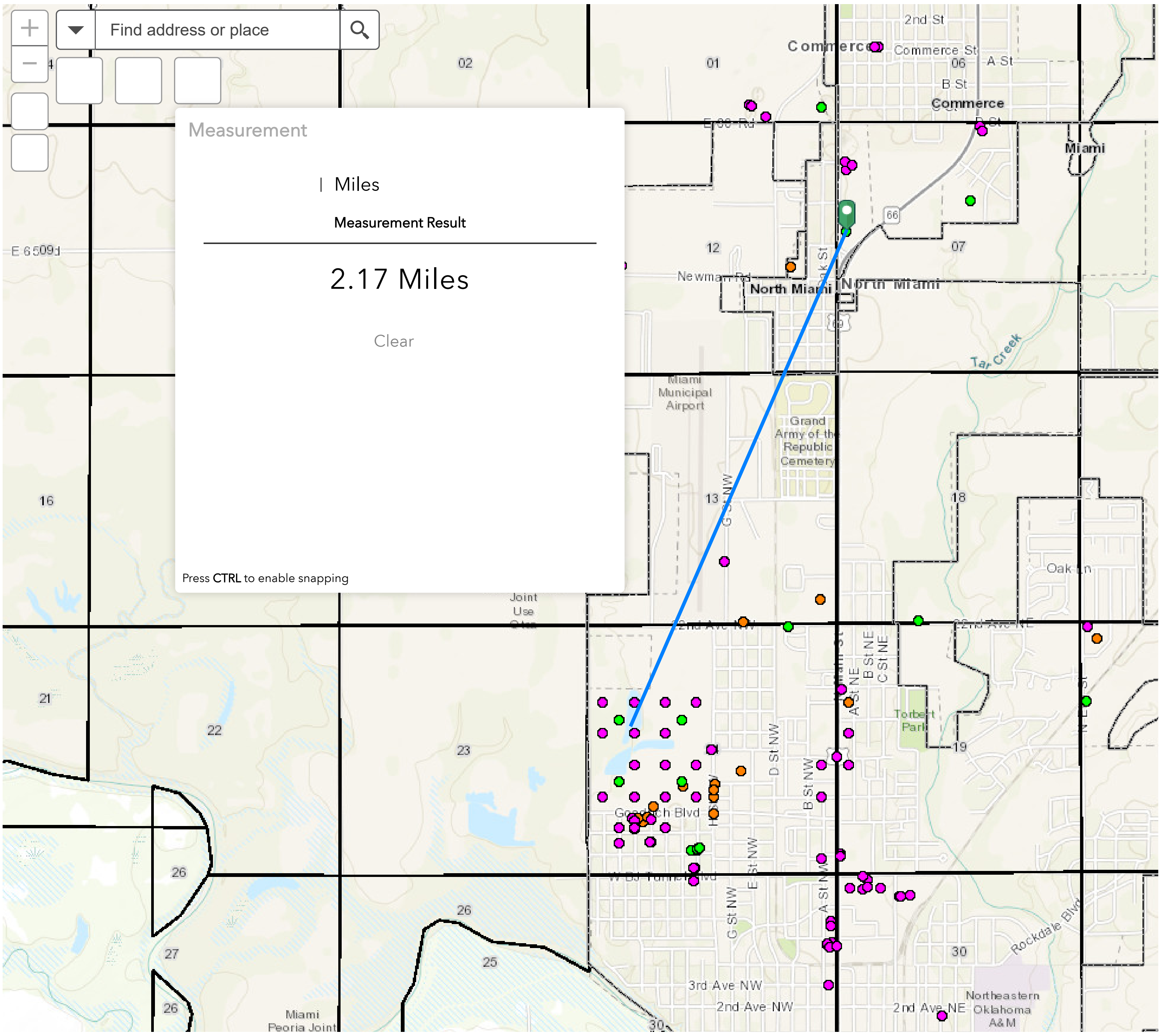
The nearest private groundwater well is approximately 2.17 miles north northeast of the site.

Wells within 4 miles of the Impoundment

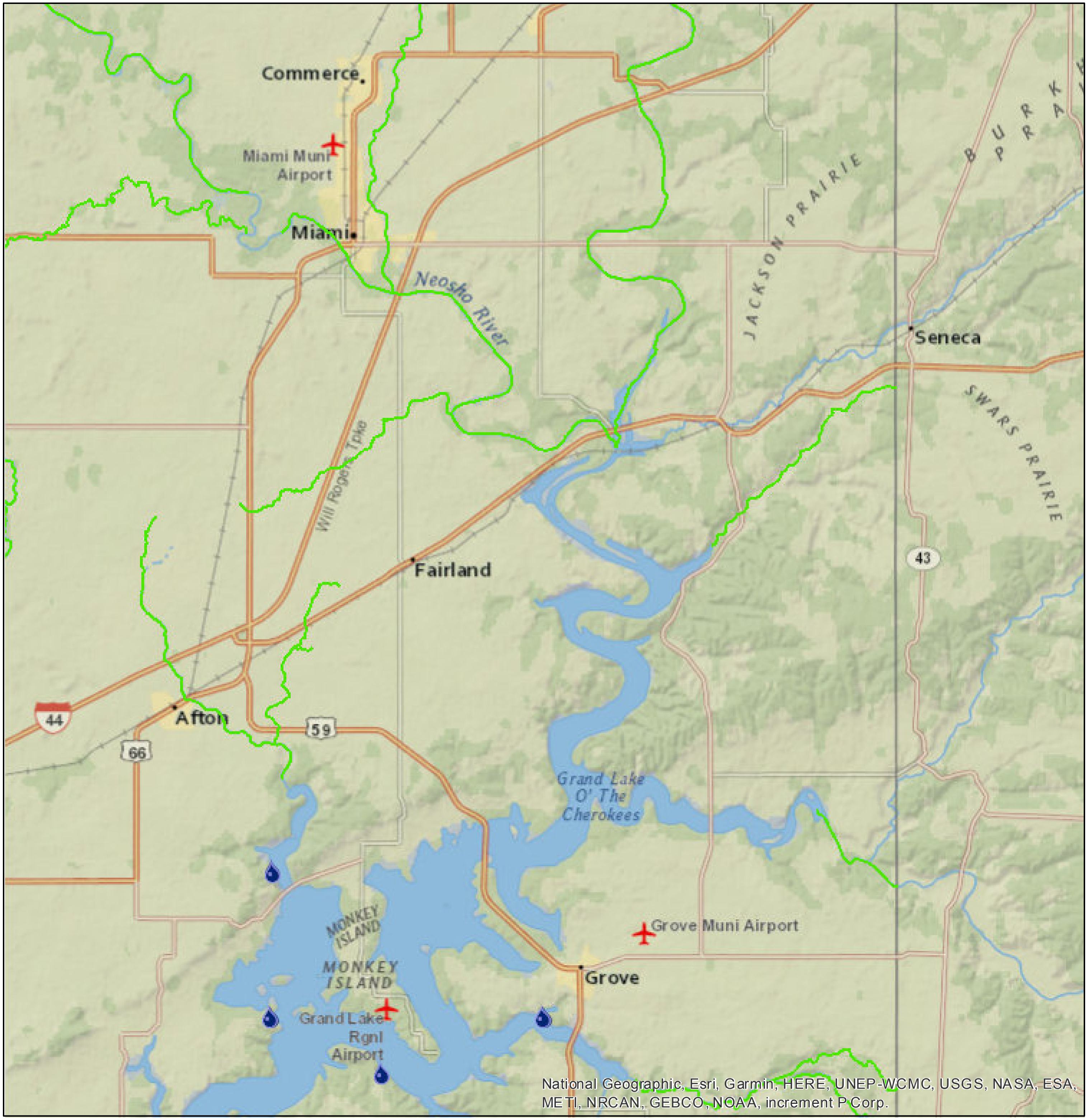
Type of wells	Number of Wells	City of Miami	City of Commerce	Quapaw Tribe	Total
Domestic	7				7
Public Water Supply	0	9	2	2	13
Commercial	0	1		1	2
Industrial	0	1		0	1
Irrigation	0	1		0	1

1. Information is gathered from the Oklahoma Department of Environmental Quality (DEQ) data viewer and DEQ databases. Population data is obtained from the United States Census Bureau. Well data is obtained from the Oklahoma Water Resources Board. https://www.owrb.ok.gov/maps/index.php


22EI
23EI
E 50 Rd
E 50 Rd
S 530 Rd
S 592 Rd
Commerce
E 60 Rd
E 60 Rd
Miami
E 65 Rd
E 65 Rd
North Miami
S 580 Rd
Miami Peoria Joint Use Otsa
Miami Municipal Airport
P St NW
S 540 Rd
28N 22EI
Miami Peoria Joint Use Otsa
OTTAWA
28N 23EI
Main St
N Elm St
Miami
Miami
Miami
Miami
S 590 Rd
Miami
Miami
S 545 Rd
OK-10
B St SE
Riverview Park
E 110 Rd
750 ft
750 ft
27N 22EI
27N 23EI
E St SW
E 120 Rd
E 120 Rd
S 520 Rd
530 Rd
69



-94.893 36.894 Degrees



PWS Surface Water Intakes 2020

Legend

- PWS Surface Water Intakes 2020
- 2018 Completed TMDLs

0 2 4 6
Miles

Date: 12/29/2020

We make every effort to provide and maintain accurate, complete, usable, and timely information. However, some data and information on this map may be preliminary or out of date and is provided with the understanding that it is not guaranteed to be correct or complete. Conclusions drawn from, or actions undertaken on the basis of, such data and information are the sole responsibility of the user.

OKLAHOMA DEPARTMENT OF ENVIRONMENTAL QUALITY

Reference 5 Underground Storage Tanks

MEMORANDUM

DATE: December 29, 2020

TO: Goodrich Asbestos Impoundment PA/SI File

FROM: Hal Cantwell
Environmental Programs Specialist

RE: Underground Storage Tank Information

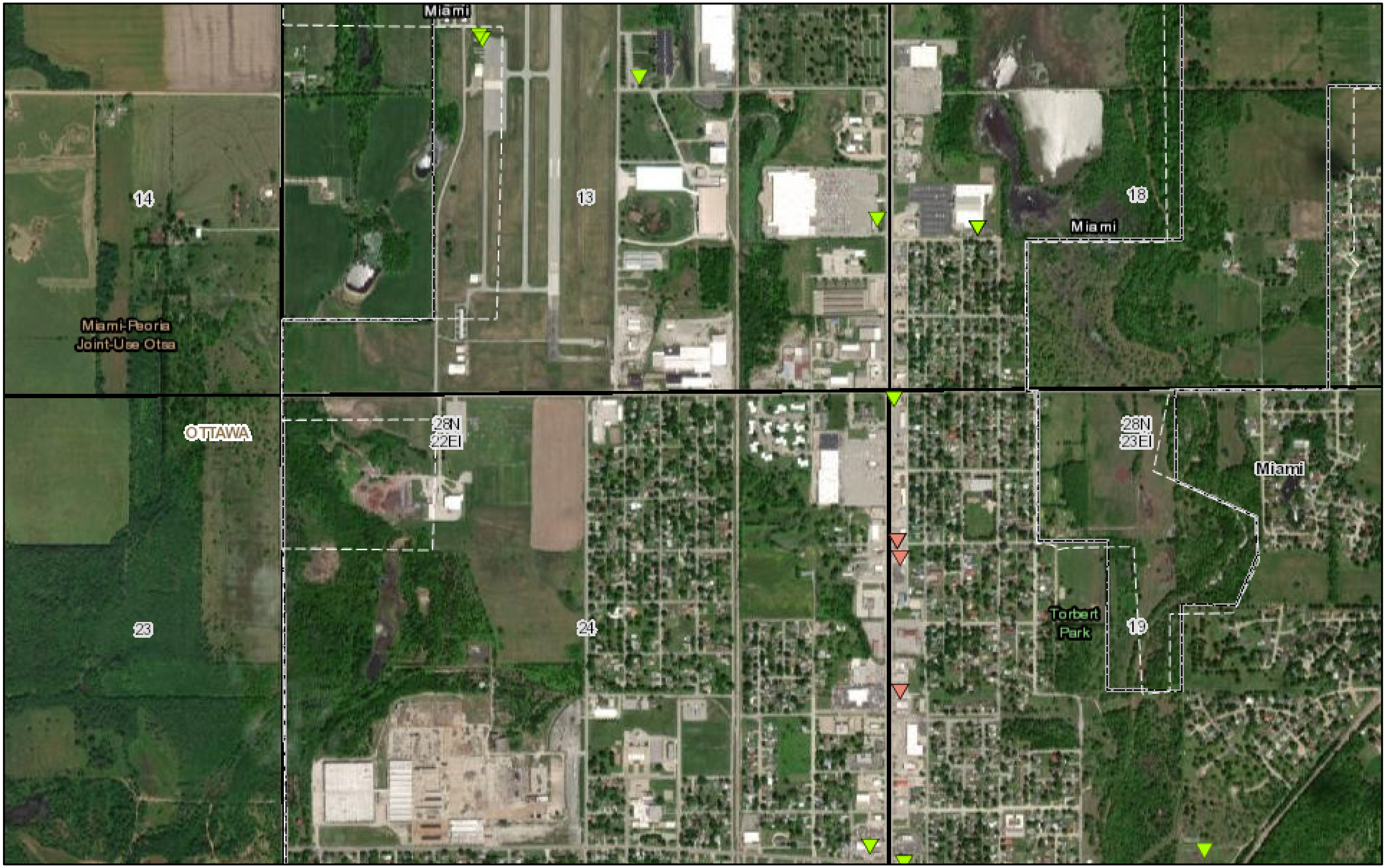
The table below summarizes the underground storage tank (UST) information within a 4-mile radius of the Goodrich Asbestos Impoundment site in Miami, Oklahoma.

Total Amount of USTs Onsite	Total Open USTs	Total Closed USTs	Total USTs
0	20	53	73

Closest UST is at Pump N Petes #17 is located approximately 4500 feet east of site.

Data for the UST information is from the Oklahoma Water Resources Board and the Environmental Protection Agency (EPA) UST Finder Map.

BFG Area UST



12/16/2020, 3:12:18 PM

Regulated Underground Storage Tanks (OCC)

Yes

No

Sections

Townships

County Boundaries

State Boundary

Municipal Boundaries

1:18,056

0 0.13 0.25 0.5 mi

0 0.17 0.35 0.7 km

USDA FSA, GeoEye, Maxar, Esri, HERE, Garmin, iPC

ArcGIS Web AppBuilder

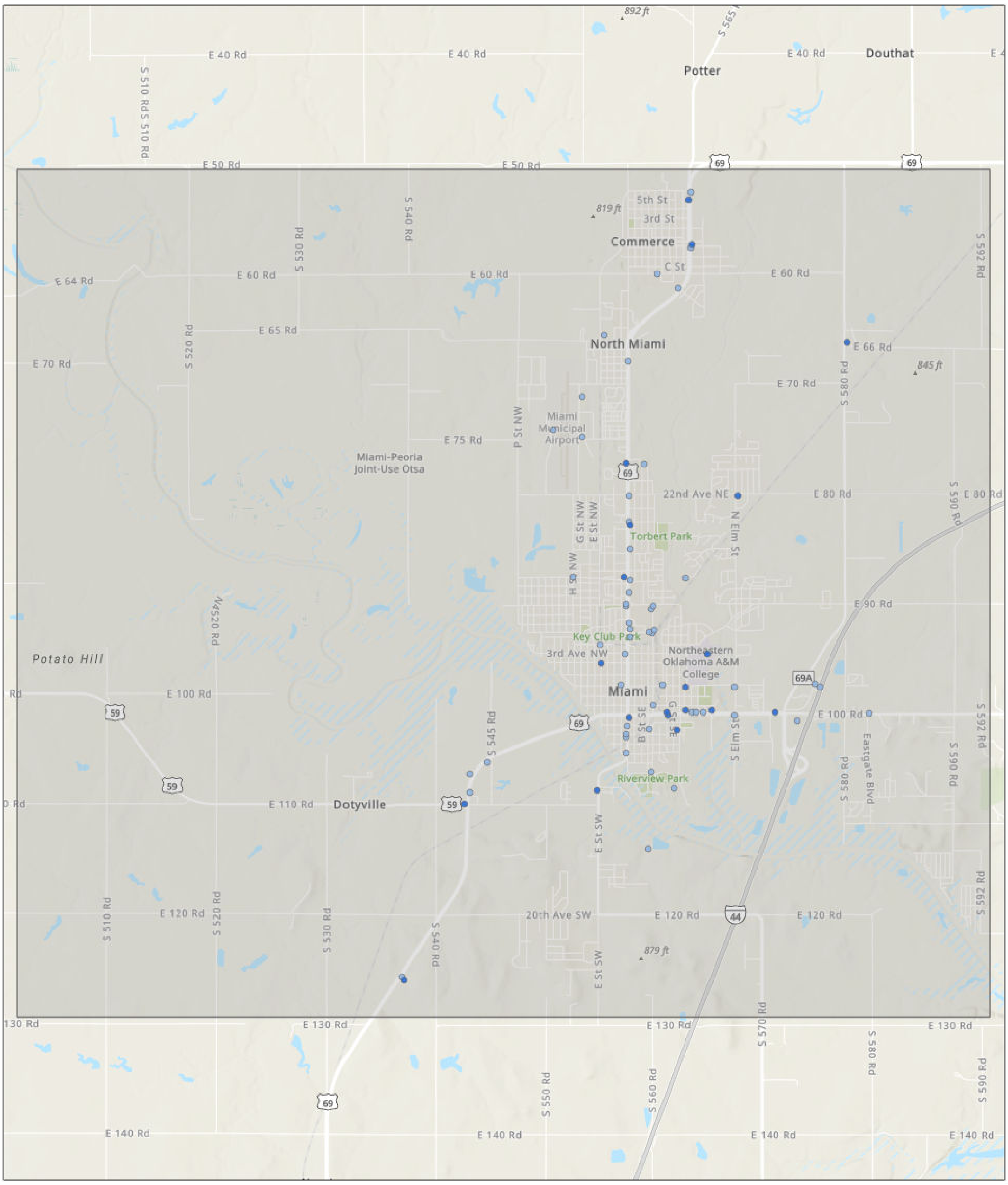
OWRB | USDA FSA, Maxar | Esri, HERE, Garmin, iPC |

Underground Storage Tank Report

BF Goodrich Impoundment USTs within 4 miles

Area : 68.37 mi²

Dec 28 2020 19:50:11 Central Standard Time



Facilities

- Closed UST(s)
- Open UST(s)

1:72,224

0 0.5 1 2 mi

0 1 2 4 km

Missouri Dept. of Conservation, Missouri DNR, Esri, HERE, Garmin, SafeGraph, METI/NASA, USGS, EPA, NPS, USDA
Esri, NASA, NGA, USGS, FEMA

Summary

Name	Count	Area(mi²)	Length(mi)
Facilities	73		
Releases	27		

Facilities

#	Facility ID	Name	Address	City	County
1	OK[5809997]	Ottawa County Maintenance Hdg	12650 S. Hwy 169	Miami	
2	OK[5813702]	Okla Dept Of Transportation	S HWY 69	Miami	
3	OK[5807437]	Lagoon Lift Station	200 15TH PL SW	Miami	
4	OK[5811280]	One Stop Convenience Store	10991 S HWY 69	Miami	
5	OK[5803384]	Kc Jeffries Oil Co	5 MI WEST OF CITY	Miami	
6	OK[5812425]	Big Daddy's BBQ	1030 E Street SW	Miami	
7	OK[5810793]	South Sewage Treatment Plant	10TH & H STREET SE	Miami	
8	OK[5809659]	Smile-A-Mile Gas-N-Serve	10651 S HWY 69	Miami	
9	OK[5805785]	Co B (-) 1/279 Inf	830 D SE	Miami	
10	OK[5810669]	Smith's Convenience Store	RT 3 BOX 242 C	Miami	
11	OK[5813451]	Riverview Auto Sales	624 S MAIN	Miami	
12	OK[5809652]	Gas & Serve	505 S MAIN	Miami	
13	OK[5807072]	Auto Detail Shop	501 N MAIN	Miami	
14	OK[5801200]	Modoc Tribe of Oklahoma	416 H St SE	Miami	
15	OK[5806191]	Bogle Stations Inc	400 D ST SE	Miami	
16	OK[5810797]	Miami Muffler Center	411 N MAIN	Miami	
17	OK[5812263]	Miami Maintenance Facility	MILE POST 314 (WILL ROGERS TPK)	Miami	
18	OK[5803957]	Otter Stop	301 S Main	Miami	
19	OK[5811300]	Lube-N-Go/Terry Lawson	610 E STEVE OWENS BLVD	Miami	
20	OK[5803380]	Okla Dept Of Transportation	1630 STEVE OWENS BLVD	Miami	
21	OK[5812665]	Dick's Place	309 EASTGATE	Miami	
22	OK[5807075]	Texaco	1225 E STEVE OWENS BLVD	Miami	
23	OK[5803390]	Red's Tire Store	1101 E STEVE OWENS BLVD	Miami	
24	OK[5803381]	Pump 'N Pete's #43	2215 E Steve Owens Blvd	Miami	
25	OK[5809657]	Joe's Tire & Oil	1125 Steve Owens Blvd	Miami	
26	OK[5801234]	Pump n Pete's #44	611 E Steve Owens Blvd	Miami	
27	OK[5804139]	Chandler's Auto Stop	1407 E STEVE OWENS BLVD	Miami	
28	OK[5803208]	Love's Country Store #73	1015 E STEVE OWENS CTR	Miami	
29	OK[5815176]	Sinclair Bulk	2ND & D ST SE	Miami	
30	OK[5811242]	Ez Go #48	WILL ROGERS TURNPIKE BOX 1141	Miami	
31	OK[5806139]	Gary's Texaco	812 E Central	Miami	
32	OK[5802802]	Collins Const. Of Miami Inc.	221 S ELM STR	Miami	
33	OK[5857170]	Former Tank Location	5 A NW Street	Miami	
34	OK[5813415]	Beachner Grain Inc	501 E CENTRAL	Miami	
35	OK[5810457]	Ss#27059	WILL ROGERS TURNPIKE	Miami	
36	OK[5811528]	Baptist Regional Health Center	200 2ND AVE SW	Miami	
37	OK[5811008]	Northeastern Oklahoma A&M College	200 I STREET NE	Miami	
38	OK[5803382]	Al's Kountry Corner	229 N MAIN	Miami	
39	OK[5807435]	Operations Center	4TH & D ST SE	Miami	
40	OK[5803389]	U-Do (Former)	1928 N MAIN	Miami	
41	OK[5803777]	City Of Miami - Street Dept	5TH & D STR NE	Miami	
42	OK[5808495]	M & M Beverage Lot (Or Ridge Lo	320 5TH NE	Miami	
43	OK[5813384]	Ottawa County Farm Supply	530 D NE	Miami	
44	OK[5813140]	Not Listed	606 MAIN	Miami	
45	OK[5805221]	City Of Miami	520 N MAIN	Miami	
46	OK[5808494]	John's Diesel Service	821 D NE	Miami	
47	OK[5802316]	Continental Baking Co.	830 NE D	Miami	
48	OK[5806204]	North Main Express	845 N MAIN	Miami	
49	OK[5809658]	North Main Total	901 N MAIN	Miami	
50	OK[5804657]	Rocor, Inc.	1014 N MAIN	Miami	
51	OK[5808826]	Hooper Auto Sales & Detailing	1202 N MAIN	Miami	
52	OK[5807436]	North Sewage Treatment Plant	14TH & H ST NE	Miami	
53	OK[5856751]	Former B.F. Goodrich Tire Manufacturing Plant	Goodrich Blvd	Miami	
54	OK[5806129]	Pump N Petes #17	10 GOODRICH BLVD	Miami	
55	OK[5809415]	Speed A Way	1602 N MAIN	Miami	
56	OK[5803206]	Pete's #10	1840 N MAIN ST	Miami	
57	OK[5807314]	Coastal Mart #9630	1900 N MAIN	Miami	
58	OK[5809655]	Miami Pit Stop	2130 N Elm St	Miami	
59	OK[5810508]	Sonny's Service	2040 N MAIN	Miami	
60	OK[5812568]	Wal-Mart Supercenter #28	2415 NW MAIN ST	Miami	
61	OK[5821010]	Murphy Usa #6867	2407 N MAIN ST	Miami	
62	OK[5806923]	Amedco Health Care Inc.	500 26TH STREET NW	Miami	
63	OK[5807074]	Miami Airport	ADDRESS UNKNOWN	Miami	
64	OK[5802211]	Miami Concrete	2840 6TH ST NW	Miami	
65	OK[5815666]	Former Cayenter-Williams Gulf	427 N Main	Miami	

66	OK[5811613]	O-Gah-Pah Convenience Center	6590 S 580 RD	Miami	
67	OK[5809934]	Bayliner Marine Corp	300 NEWMAN ROAD	Miami	
68	OK[5809291]	Commerce Automotive	602 S JEFFERSON	Commerce	
69	OK[5801253]	Commerce High School	420 D STR	Commerce	
70	OK[5802626]	Ralph Mullen & Jim Mullen	203 S JEFFERSON	Commerce	
71	OK[5804460]	Tiger Stop	105 S Mickey Mantle	Commerce	
72	OK[5805474]	L&M Convenience Store	501 MICKEY MANTLE BLVD	Commerce	
73	OK[5810135]	Commerce Super Service	520 N Jefferson (Hwy 69)	Commerce	

Reference 6 Warranty Deed

I-2020-002091 Book1110 Pg:575
05/21/2020 10:55 am $22.00
Robyn Mitchell - Ottawa County Clerk

OTTAWA COUNTY 1907

SPECIAL WARRANTY DEED

THIS SPECIAL WARRANTY DEED made this 10th day of April, 2020, by **ALLAN KASPAR** ("Seller"), to and for the benefit of **REAL ESTATE REMEDIATION. LLC, a foreign limited liability company**, whose address is 3519 Greensboro Avenue, Tuscaloosa, Alabama 35401, ("Buyer").

WITNESSETH that,

WHEREAS, on the 7th day of May, 2014, Buyer and Seller entered into a certain Purchase and Sale Agreement pursuant to which Buyer sold to Seller certain real property ("Property") located in Ottawa County, Oklahoma, and more particularly described hereinafter; and

NOW, THEREFORE, in consideration of the premises, the payment by Buyer to Seller of Ten Dollars ($10.00), and other good and valuable consideration, the receipt and sufficiency of which are hereby acknowledged Seller does hereby **CONVEY** and **WARRANT SPECIALLY**, as hereinafter recited, unto the Buyer, **REAL ESTATE REMEDIATION. LLC, a foreign limited liability company**, and its successors and assigns, forever, but only to the extent owned by Seller, all of that real property ("Property"), in, on and under said Property, located in Ottawa County, State of Oklahoma which is described as follows:

The South Half of the Northwest Quarter and the North Half of the Southwest Quarter of Section 24, Township 28 North, Range 22 East of the Indian Base and Meridian, Ottawa County, Oklahoma;

LESS AND EXCEPT:

A tract of land lying in the N½ SW¼ and the S½ NW¼ of Section 24, Township 28 North, Range 22 East of the Indian Meridian, Ottawa County, Oklahoma, more particularly described as follows to-wit:

Commencing at the NW corner of the N½ SW¼ of said Section 24; Thence S 00° 34' 16" E, 242.68 feet; Thence N 89° 08' 38" E, 943.58 feet to the point of beginning; Thence N 00° 50' 41" W, 534.58 feet; Thence N 89° 07' 14" E, 1706.68 feet; Thence S 00° 20' 00" E, 291.53 feet; Thence S 00° 30' 26" E, 1320.76 feet; Thence S 89° 08' 10" W, 1477.92 feet; Thence N 00° 50' 41" W, 1077.19 feet; Thence S 89° 08' 38" W, 218.36 feet to the point of beginning.

GranTee Address: 3519 Greensboro Ave
Tuscaloosa, Alabama 35401

This conveyance is subject to all rights-of-way, easements, *leases to Discovery Plastics LLC and Fortiflex Plastics*, deed and plat restrictions, partitions, severances, encumbrances, licenses, reservations and exceptions which are of record and/or in use as of the date first above written, unpaid and accruing ad valorem taxes, and interst and penalties thereon, existing judgment liens of materialmen providing demolition services upon the property at the request of Buyer, existing environmental conditions or regulatory proceedings resulting therefrom, all rights of persons in possession and to physical

STATE OF OKLAHOMA
OTTAWA County
Documentary Stamps: $2100.00

Reference 7 Soils Survey Report

United States Department of Agriculture

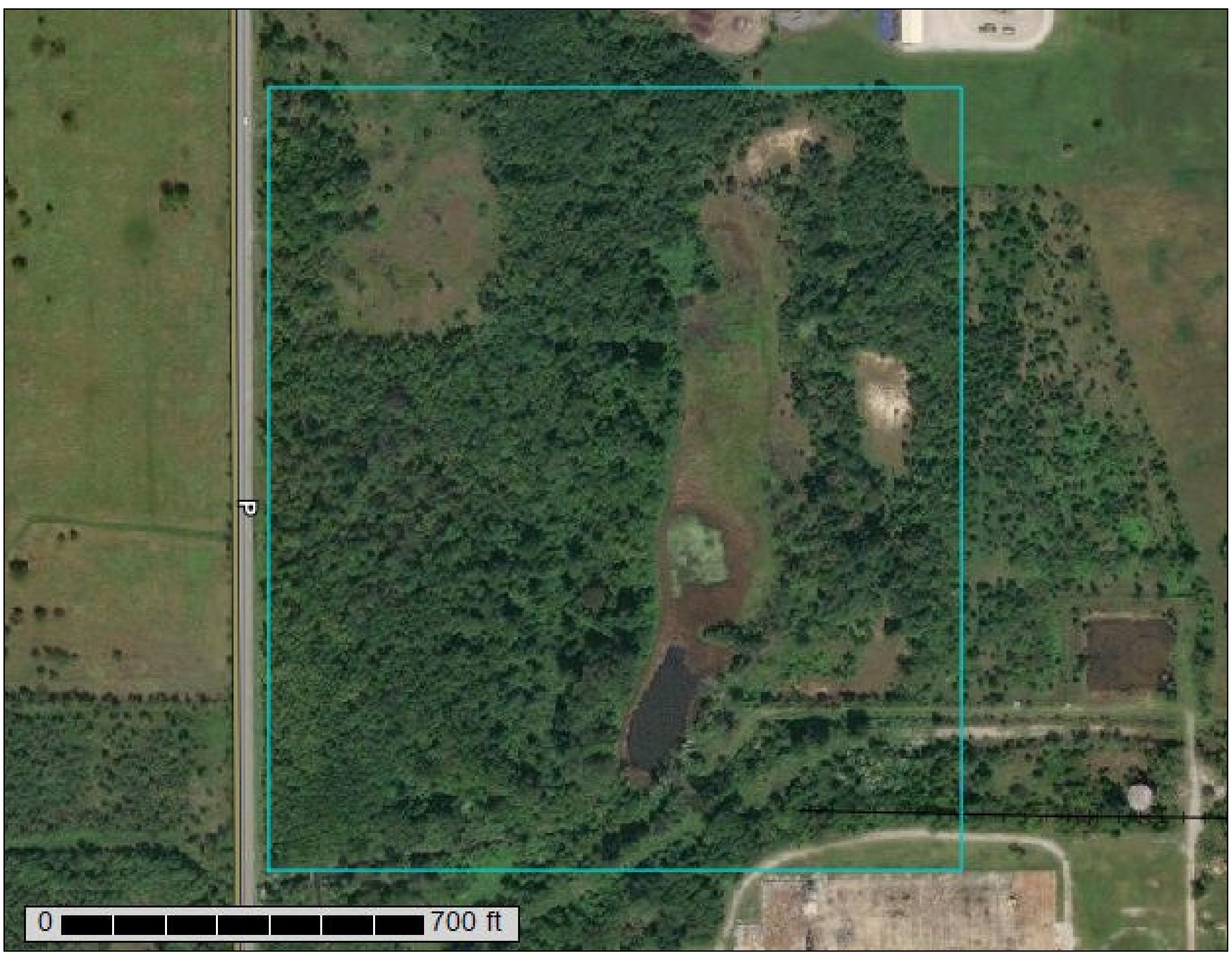
NRCS

Natural Resources Conservation Service

A product of the National Cooperative Soil Survey, a joint effort of the United States Department of Agriculture and other Federal agencies, State agencies including the Agricultural Experiment Stations, and local participants

Custom Soil Resource Report for

Ottawa County, Oklahoma



December 14, 2020

Preface

Soil surveys contain information that affects land use planning in survey areas. They highlight soil limitations that affect various land uses and provide information about the properties of the soils in the survey areas. Soil surveys are designed for many different users, including farmers, ranchers, foresters, agronomists, urban planners, community officials, engineers, developers, builders, and home buyers. Also, conservationists, teachers, students, and specialists in recreation, waste disposal, and pollution control can use the surveys to help them understand, protect, or enhance the environment.

Various land use regulations of Federal, State, and local governments may impose special restrictions on land use or land treatment. Soil surveys identify soil properties that are used in making various land use or land treatment decisions. The information is intended to help the land users identify and reduce the effects of soil limitations on various land uses. The landowner or user is responsible for identifying and complying with existing laws and regulations.

Although soil survey information can be used for general farm, local, and wider area planning, onsite investigation is needed to supplement this information in some cases. Examples include soil quality assessments (http://www.nrcs.usda.gov/wps/portal/nrcs/main/soils/health/) and certain conservation and engineering applications. For more detailed information, contact your local USDA Service Center (https://offices.sc.egov.usda.gov/locator/app?agency=nrcs) or your NRCS State Soil Scientist (http://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/contactus/?cid=nrcs142p2_053951).

Great differences in soil properties can occur within short distances. Some soils are seasonally wet or subject to flooding. Some are too unstable to be used as a foundation for buildings or roads. Clayey or wet soils are poorly suited to use as septic tank absorption fields. A high water table makes a soil poorly suited to basements or underground installations.

The National Cooperative Soil Survey is a joint effort of the United States Department of Agriculture and other Federal agencies, State agencies including the Agricultural Experiment Stations, and local agencies. The Natural Resources Conservation Service (NRCS) has leadership for the Federal part of the National Cooperative Soil Survey.

Information about soils is updated periodically. Updated information is available through the NRCS Web Soil Survey, the site for official soil survey information.

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Contents

How Soil Surveys Are Made

Soil surveys are made to provide information about the soils and miscellaneous areas in a specific area. They include a description of the soils and miscellaneous areas and their location on the landscape and tables that show soil properties and limitations affecting various uses. Soil scientists observed the steepness, length, and shape of the slopes; the general pattern of drainage; the kinds of crops and native plants; and the kinds of bedrock. They observed and described many soil profiles. A soil profile is the sequence of natural layers, or horizons, in a soil. The profile extends from the surface down into the unconsolidated material in which the soil formed or from the surface down to bedrock. The unconsolidated material is devoid of roots and other living organisms and has not been changed by other biological activity.

Currently, soils are mapped according to the boundaries of major land resource areas (MLRAs). MLRAs are geographically associated land resource units that share common characteristics related to physiography, geology, climate, water resources, soils, biological resources, and land uses (USDA, 2006). Soil survey areas typically consist of parts of one or more MLRA.

The soils and miscellaneous areas in a survey area occur in an orderly pattern that is related to the geology, landforms, relief, climate, and natural vegetation of the area. Each kind of soil and miscellaneous area is associated with a particular kind of landform or with a segment of the landform. By observing the soils and miscellaneous areas in the survey area and relating their position to specific segments of the landform, a soil scientist develops a concept, or model, of how they were formed. Thus, during mapping, this model enables the soil scientist to predict with a considerable degree of accuracy the kind of soil or miscellaneous area at a specific location on the landscape.

Commonly, individual soils on the landscape merge into one another as their characteristics gradually change. To construct an accurate soil map, however, soil scientists must determine the boundaries between the soils. They can observe only a limited number of soil profiles. Nevertheless, these observations, supplemented by an understanding of the soil-vegetation-landscape relationship, are sufficient to verify predictions of the kinds of soil in an area and to determine the boundaries.

Soil scientists recorded the characteristics of the soil profiles that they studied. They noted soil color, texture, size and shape of soil aggregates, kind and amount of rock fragments, distribution of plant roots, reaction, and other features that enable them to identify soils. After describing the soils in the survey area and determining their properties, the soil scientists assigned the soils to taxonomic classes (units). Taxonomic classes are concepts. Each taxonomic class has a set of soil characteristics with precisely defined limits. The classes are used as a basis for comparison to classify soils systematically. Soil taxonomy, the system of taxonomic classification used in the United States, is based mainly on the kind and character of soil properties and the arrangement of horizons within the profile. After the soil scientists classified and named the soils in the survey area, they compared the individual soils with similar soils in the same taxonomic class in other areas so that they could confirm data and assemble additional data based on experience and research.

The objective of soil mapping is not to delineate pure map unit components; the objective is to separate the landscape into landforms or landform segments that have similar use and management requirements. Each map unit is defined by a unique combination of soil components and/or miscellaneous areas in predictable proportions. Some components may be highly contrasting to the other components of the map unit. The presence of minor components in a map unit in no way diminishes the usefulness or accuracy of the data. The delineation of such landforms and landform segments on the map provides sufficient information for the development of resource plans. If intensive use of small areas is planned, onsite investigation is needed to define and locate the soils and miscellaneous areas.

Soil scientists make many field observations in the process of producing a soil map. The frequency of observation is dependent upon several factors, including scale of mapping, intensity of mapping, design of map units, complexity of the landscape, and experience of the soil scientist. Observations are made to test and refine the soil-landscape model and predictions and to verify the classification of the soils at specific locations. Once the soil-landscape model is refined, a significantly smaller number of measurements of individual soil properties are made and recorded. These measurements may include field measurements, such as those for color, depth to bedrock, and texture, and laboratory measurements, such as those for content of sand, silt, clay, salt, and other components. Properties of each soil typically vary from one point to another across the landscape.

Observations for map unit components are aggregated to develop ranges of characteristics for the components. The aggregated values are presented. Direct measurements do not exist for every property presented for every map unit component. Values for some properties are estimated from combinations of other properties.

While a soil survey is in progress, samples of some of the soils in the area generally are collected for laboratory analyses and for engineering tests. Soil scientists interpret the data from these analyses and tests as well as the field-observed characteristics and the soil properties to determine the expected behavior of the soils under different uses. Interpretations for all of the soils are field tested through observation of the soils in different uses and under different levels of management. Some interpretations are modified to fit local conditions, and some new interpretations are developed to meet local needs. Data are assembled from other sources, such as research information, production records, and field experience of specialists. For example, data on crop yields under defined levels of management are assembled from farm records and from field or plot experiments on the same kinds of soil.

Predictions about soil behavior are based not only on soil properties but also on such variables as climate and biological activity. Soil conditions are predictable over long periods of time, but they are not predictable from year to year. For example, soil scientists can predict with a fairly high degree of accuracy that a given soil will have a high water table within certain depths in most years, but they cannot predict that a high water table will always be at a specific level in the soil on a specific date.

After soil scientists located and identified the significant natural bodies of soil in the survey area, they drew the boundaries of these bodies on aerial photographs and identified each as a specific map unit. Aerial photographs show trees, buildings, fields, roads, and rivers, all of which help in locating boundaries accurately.

Soil Map

The soil map section includes the soil map for the defined area of interest, a list of soil map units on the map and extent of each map unit, and cartographic symbols displayed on the map. Also presented are various metadata about data used to produce the map, and a description of each soil map unit.

Custom Soil Resource Report
Soil Map (BFG Impoundments 5)

MAP LEGEND

Area of Interest (AOI)

- Area of Interest (AOI)

Soils

- Soil Map Unit Polygons
- Soil Map Unit Lines
- Soil Map Unit Points

Special Point Features

- Blowout
- Borrow Pit
- Clay Spot
- Closed Depression
- Gravel Pit
- Gravelly Spot
- Landfill
- Lava Flow
- Marsh or swamp
- Mine or Quarry
- Miscellaneous Water
- Perennial Water
- Rock Outcrop
- Saline Spot
- Sandy Spot
- Severely Eroded Spot
- Sinkhole
- Slide or Slip
- Sodic Spot
- Spoil Area
- Stony Spot
- Very Stony Spot
- Wet Spot
- Other
- Special Line Features

Water Features

- Streams and Canals

Transportation

- Rails
- Interstate Highways
- US Routes
- Major Roads
- Local Roads

Background

- Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:24,000.

Warning: Soil Map may not be valid at this scale.

Enlargement of maps beyond the scale of mapping can cause misunderstanding of the detail of mapping and accuracy of soil line placement. The maps do not show the small areas of contrasting soils that could have been shown at a more detailed scale.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL:
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Ottawa County, Oklahoma
Survey Area Data: Version 15, May 27, 2020

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Aug 31, 2015—Nov 18, 2017

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Map Unit Legend (BFG Impoundments 5)

Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
Ln	Lightning silt loam, 0 to 1 percent slopes, occasionally flooded	17.9	38.8%
PaB	Parsons silt loam, 1 to 3 percent slopes	15.8	34.1%
Prqg	Pits, gravel and quarry	12.1	26.2%
TaA	Taloka silt loam, 0 to 1 percent slopes	0.4	0.9%
Totals for Area of Interest		**46.3**	**100.0%**

Map Unit Descriptions (BFG Impoundments 5)

The map units delineated on the detailed soil maps in a soil survey represent the soils or miscellaneous areas in the survey area. The map unit descriptions, along with the maps, can be used to determine the composition and properties of a unit.

A map unit delineation on a soil map represents an area dominated by one or more major kinds of soil or miscellaneous areas. A map unit is identified and named according to the taxonomic classification of the dominant soils. Within a taxonomic class there are precisely defined limits for the properties of the soils. On the landscape, however, the soils are natural phenomena, and they have the characteristic variability of all natural phenomena. Thus, the range of some observed properties may extend beyond the limits defined for a taxonomic class. Areas of soils of a single taxonomic class rarely, if ever, can be mapped without including areas of other taxonomic classes. Consequently, every map unit is made up of the soils or miscellaneous areas for which it is named and some minor components that belong to taxonomic classes other than those of the major soils.

Most minor soils have properties similar to those of the dominant soil or soils in the map unit, and thus they do not affect use and management. These are called noncontrasting, or similar, components. They may or may not be mentioned in a particular map unit description. Other minor components, however, have properties and behavioral characteristics divergent enough to affect use or to require different management. These are called contrasting, or dissimilar, components. They generally are in small areas and could not be mapped separately because of the scale used. Some small areas of strongly contrasting soils or miscellaneous areas are identified by a special symbol on the maps. If included in the database for a given area, the contrasting minor components are identified in the map unit descriptions along with some characteristics of each. A few areas of minor components may not have been observed, and consequently they are not mentioned in the descriptions, especially where the pattern was so complex that it was impractical to make enough observations to identify all the soils and miscellaneous areas on the landscape.

The presence of minor components in a map unit in no way diminishes the usefulness or accuracy of the data. The objective of mapping is not to delineate pure taxonomic classes but rather to separate the landscape into landforms or landform segments that have similar use and management requirements. The delineation of such segments on the map provides sufficient information for the development of resource plans. If intensive use of small areas is planned, however, onsite investigation is needed to define and locate the soils and miscellaneous areas.

An identifying symbol precedes the map unit name in the map unit descriptions. Each description includes general facts about the unit and gives important soil properties and qualities.

Soils that have profiles that are almost alike make up a *soil series*. Except for differences in texture of the surface layer, all the soils of a series have major horizons that are similar in composition, thickness, and arrangement.

Soils of one series can differ in texture of the surface layer, slope, stoniness, salinity, degree of erosion, and other characteristics that affect their use. On the basis of such differences, a soil series is divided into *soil phases*. Most of the areas shown on the detailed soil maps are phases of soil series. The name of a soil phase commonly indicates a feature that affects use or management. For example, Alpha silt loam, 0 to 2 percent slopes, is a phase of the Alpha series.

Some map units are made up of two or more major soils or miscellaneous areas. These map units are complexes, associations, or undifferentiated groups.

A *complex* consists of two or more soils or miscellaneous areas in such an intricate pattern or in such small areas that they cannot be shown separately on the maps. The pattern and proportion of the soils or miscellaneous areas are somewhat similar in all areas. Alpha-Beta complex, 0 to 6 percent slopes, is an example.

An *association* is made up of two or more geographically associated soils or miscellaneous areas that are shown as one unit on the maps. Because of present or anticipated uses of the map units in the survey area, it was not considered practical or necessary to map the soils or miscellaneous areas separately. The pattern and relative proportion of the soils or miscellaneous areas are somewhat similar. Alpha-Beta association, 0 to 2 percent slopes, is an example.

An *undifferentiated group* is made up of two or more soils or miscellaneous areas that could be mapped individually but are mapped as one unit because similar interpretations can be made for use and management. The pattern and proportion of the soils or miscellaneous areas in a mapped area are not uniform. An area can be made up of only one of the major soils or miscellaneous areas, or it can be made up of all of them. Alpha and Beta soils, 0 to 2 percent slopes, is an example.

Some surveys include *miscellaneous areas*. Such areas have little or no soil material and support little or no vegetation. Rock outcrop is an example.

Ottawa County, Oklahoma

Ln—Lightning silt loam, 0 to 1 percent slopes, occasionally flooded

Map Unit Setting

National map unit symbol: 2w21y
Elevation: 450 to 1,200 feet
Mean annual precipitation: 36 to 45 inches
Mean annual air temperature: 58 to 65 degrees F
Frost-free period: 200 to 220 days
Farmland classification: All areas are prime farmland

Map Unit Composition

Lightning and similar soils: 90 percent
Minor components: 10 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Lightning

Setting

Landform: Flood-plain steps
Landform position (three-dimensional): Tread
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Loamy and clayey alluvium

Typical profile

A - 0 to 7 inches: silt loam
E - 7 to 14 inches: silt loam
Btg1 - 14 to 22 inches: silty clay loam
Btg2 - 22 to 62 inches: silty clay
C - 62 to 79 inches: silty clay

Properties and qualities

Slope: 0 to 1 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Poorly drained
Capacity of the most limiting layer to transmit water (Ksat): Low to moderately high (0.00 to 0.20 in/hr)
Depth to water table: About 6 to 24 inches
Frequency of flooding: Occasional
Frequency of ponding: None
Maximum salinity: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Available water capacity: High (about 10.4 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 3w
Hydrologic Soil Group: D
Ecological site: R112XY124KS - Wet Floodplain
Hydric soil rating: Yes

Minor Components

Verdigris

Percent of map unit: 5 percent

Landform: Flood plains
Landform position (three-dimensional): Tread
Down-slope shape: Linear
Across-slope shape: Linear
Ecological site: R112XY125KS - Loamy Floodplain
Hydric soil rating: No

Mason

Percent of map unit: 3 percent
Landform: Stream terraces
Landform position (three-dimensional): Tread
Down-slope shape: Linear
Across-slope shape: Linear
Ecological site: R112XY123KS - Loamy Terrace
Hydric soil rating: No

Osage

Percent of map unit: 2 percent
Landform: Flood plains
Landform position (three-dimensional): Tread
Down-slope shape: Linear
Across-slope shape: Linear
Ecological site: R112XY124KS - Wet Floodplain
Hydric soil rating: Yes

PaB—Parsons silt loam, 1 to 3 percent slopes

Map Unit Setting

National map unit symbol: 2thdy
Elevation: 470 to 1,130 feet
Mean annual precipitation: 38 to 44 inches
Mean annual air temperature: 55 to 61 degrees F
Frost-free period: 175 to 230 days
Farmland classification: All areas are prime farmland

Map Unit Composition

Parsons and similar soils: 90 percent
Minor components: 10 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Parsons

Setting

Landform: Divides
Landform position (two-dimensional): Summit, shoulder
Landform position (three-dimensional): Interfluve
Down-slope shape: Concave
Across-slope shape: Concave
Parent material: Loess over clayey alluvium and/or clayey residuum weathered from clayey shale

Typical profile

Ap - 0 to 8 inches: silt loam
E - 8 to 14 inches: silt loam
2Btg1 - 14 to 24 inches: silty clay
2Btg2 - 24 to 59 inches: silty clay
2BC - 59 to 79 inches: silty clay loam

Properties and qualities

Slope: 1 to 3 percent
Depth to restrictive feature: 9 to 17 inches to abrupt textural change
Drainage class: Somewhat poorly drained
Capacity of the most limiting layer to transmit water (Ksat): Very low to moderately low (0.00 to 0.06 in/hr)
Depth to water table: About 6 to 18 inches
Frequency of flooding: None
Frequency of ponding: None
Gypsum, maximum content: 6 percent
Maximum salinity: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Available water capacity: Very low (about 2.9 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 3s
Hydrologic Soil Group: D
Ecological site: R112XY101KS - Claypan Upland
Hydric soil rating: No

Minor Components

Dennis

Percent of map unit: 5 percent
Landform: Interfluves
Landform position (two-dimensional): Footslope
Landform position (three-dimensional): Base slope
Down-slope shape: Convex
Across-slope shape: Convex
Ecological site: R112XY103KS - Loamy Upland
Hydric soil rating: No

Pharoah

Percent of map unit: 3 percent
Landform: Paleoterraces
Landform position (three-dimensional): Tread
Down-slope shape: Concave
Across-slope shape: Linear
Ecological site: R112XY102KS - Clayey Upland
Hydric soil rating: No

Bates

Percent of map unit: 2 percent
Landform: Interfluves
Landform position (two-dimensional): Summit, shoulder
Landform position (three-dimensional): Interfluve
Down-slope shape: Convex
Across-slope shape: Convex
Ecological site: R112XY103KS - Loamy Upland

Hydric soil rating: No

Prqg—Pits, gravel and quarry

Map Unit Setting

National map unit symbol: 2ydsy
Elevation: 670 to 1,210 feet
Mean annual precipitation: 37 to 45 inches
Mean annual air temperature: 55 to 59 degrees F
Frost-free period: 175 to 215 days
Farmland classification: Not prime farmland

Map Unit Composition

Pits, gravel and quarry: 100 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Pits, Gravel And Quarry

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 8
Hydric soil rating: Unranked

TaA—Taloka silt loam, 0 to 1 percent slopes

Map Unit Setting

National map unit symbol: 2thf3
Elevation: 500 to 1,200 feet
Mean annual precipitation: 37 to 45 inches
Mean annual air temperature: 54 to 63 degrees F
Frost-free period: 185 to 255 days
Farmland classification: All areas are prime farmland

Map Unit Composition

Taloka and similar soils: 92 percent
Minor components: 8 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Taloka

Setting

Landform: Paleoterraces
Landform position (three-dimensional): Tread
Down-slope shape: Convex
Across-slope shape: Linear

Parent material: Loamy and clayey alluvium and/or loamy and clayey colluvium over residuum weathered from sandstone and shale

Typical profile

Ap - 0 to 8 inches: silt loam
E - 8 to 20 inches: silt loam
2Btg1 - 20 to 24 inches: silty clay
2Btg2 - 24 to 39 inches: silty clay
2BC - 39 to 59 inches: silty clay loam
2C - 59 to 79 inches: silty clay loam

Properties and qualities

Slope: 0 to 1 percent
Depth to restrictive feature: 9 to 24 inches to abrupt textural change
Drainage class: Somewhat poorly drained
Capacity of the most limiting layer to transmit water (Ksat): Very low to moderately low (0.00 to 0.06 in/hr)
Depth to water table: About 6 to 18 inches
Frequency of flooding: None
Frequency of ponding: None
Gypsum, maximum content: 6 percent
Maximum salinity: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Available water capacity: Low (about 4.2 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 3s
Hydrologic Soil Group: D
Ecological site: R112XY101KS - Claypan Upland
Hydric soil rating: No

Minor Components

Dennis

Percent of map unit: 4 percent
Landform: Interfluves
Landform position (two-dimensional): Footslope
Landform position (three-dimensional): Base slope
Down-slope shape: Convex
Across-slope shape: Convex
Ecological site: R112XY103KS - Loamy Upland
Hydric soil rating: No

Bates

Percent of map unit: 3 percent
Landform: Interfluves
Landform position (two-dimensional): Summit, shoulder
Landform position (three-dimensional): Interfluve
Down-slope shape: Convex
Across-slope shape: Convex
Ecological site: R112XY103KS - Loamy Upland
Hydric soil rating: No

Aquolls

Percent of map unit: 1 percent
Landform: Divides
Landform position (two-dimensional): Summit

Landform position (three-dimensional): Interfluve
Down-slope shape: Concave
Across-slope shape: Concave
Hydric soil rating: Yes

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Reference 8 Groundwater , Geology and Hydrology Memo

Memorandum

May 27, 2020

To: Miami Goodrich, PA File

From: Kelsey Bufford, Environmental Programs Specialist

Re: Hydrogeology and Groundwater Use
Goodrich Asbestos Retention Ponds
East of P Street NW; Approximately ½ mile north of Goodrich Blvd
Miami, OK 74354
NW ¼ of Section 24 T28N R22E
Ottawa County, Oklahoma

Ottawa County is in the Central Lowland physiographic province. The summers are hot, and the winters are cool. The mean annual precipitation is 45 inches, and the average annual runoff is approximately 7 – 12 inches.

<u>Geology</u>
The Goodrich asbestos retention ponds sit on the Pennsylvanian-age McAlester and Hartshorne Formations. The McAlester Formation consists of dark gray to medium gray, well-laminated, concretionary, silty, clay shale. The base of the formation is the Warner Sandstone unit, and is predominantly a dusky yellow color, planar laminated to thin-bedded, fine-grained siliceous sandstone. Overall thickness of the McAlester Formation is approximately 350 feet.

The McAlester Formation is underlain by the Hartshorne Formation. The Hartshorne Formation is dark gray to medium dark gray, well-laminated to fissile, slightly silty clay shale. Rare coal beds with under clay and concretionary horizons occur locally in the upper part of the unit. Thickness ranges from about 75 – 80 feet.

<u>Hydrogeology</u>
Shallow groundwater beneath the ponds is found approximately 10 – 20 feet below ground surface. The general direction of flow is southward toward the Neosho River. Except for the Warner Sandstone member at the base of the McAlester Formation, the McAlester and Hartshorne Formations yield only small amounts of fair to poor quality water. The Warner Sandstone probably will yield small to moderate amounts of fair-quality water locally.

The ponds are located in the potential recharge area for the Keokuk and Reed Springs (or Boone) Formation and Roubidoux Formation bedrock aquifers. The Keokuk and Reed Springs Formation is approximately 200 feet below ground surface. Thickness ranges from about 250 – 400 feet, and wells producing from this aquifer commonly yield 3 – 50 gallons per minute (gpm) of water that is of good quality (generally less than 500 mg/L dissolved solids). The Roubidoux thickness generally ranges from 200 – 500 feet and averages about

150 feet. The aquifer is located approximately 500 – 1,500 feet below ground surface. Wells commonly yield 50 – 250 gpm, and the water is of good to fair quality (generally 150 to 1,500 mg/L dissolved solids).

There are two public water supply wells located 1.83 miles east and 1.72 miles southeast of the ponds respectively. The wells reach water at approximately 400 – 500 feet below ground surface.

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Reference 9 Census, Population and Environmental Justice

EJSCREEN Census 2010 Summary Report

Location: User-specified polygonal location
Ring (buffer): 0-mile radius
Description:

Summary	Census 2010
Population	1,055
Population Density (per sq. mile)	5,559
Minority Population	358
% Minority	34%
Households	406
Housing Units	448
Land Area (sq. miles)	0.19
% Land Area	100%
Water Area (sq. miles)	0.00
% Water Area	0%

Population by Race	Number	Percent
Total	1,055	-------
Population Reporting One Race	956	91%
White	716	68%
Black	6	1%
American Indian	175	17%
Asian	3	0%
Pacific Islander	25	2%
Some Other Race	31	3%
Population Reporting Two or More Races	99	9%
Total Hispanic Population	67	6%
Total Non-Hispanic Population	988	94%
White Alone	697	66%
Black Alone	6	1%
American Indian Alone	166	16%
Non-Hispanic Asian Alone	3	0%
Pacific Islander Alone	25	2%
Other Race Alone	1	0%
Two or More Races Alone	90	9%

Population by Sex	Number	Percent
Male	505	48%
Female	550	52%

Population by Age	Number	Percent
Age 0-4	116	11%
Age 0-17	313	30%
Age 18+	742	70%
Age 65+	116	11%

Households by Tenure	Number	Percent
Total	406	
Owner Occupied	252	62%
Renter Occupied	154	38%

Data Note: Detail may not sum to totals due to rounding. Hispanic population can be of any race.
Source: U.S. Census Bureau, Census 2010 Summary File 1.

EJSCREEN ACS Summary Report

Location: User-specified polygonal location
Ring (buffer): 0-mile radius
Description:

Summary of ACS Estimates	2013 - 2017
Population	1,024
Population Density (per sq. mile)	5,395
Minority Population	389
% Minority	38%
Households	402
Housing Units	472
Housing Units Built Before 1950	208
Per Capita Income	15,885
Land Area (sq. miles) (Source: SF1)	0.19
% Land Area	100%
Water Area (sq. miles) (Source: SF1)	0.00
% Water Area	0%

	2013 - 2017 ACS Estimates	Percent	MOE (±)
Population by Race			
Total	1,024	100%	74
Population Reporting One Race	870	85%	200
White	676	66%	82
Black	4	0%	5
American Indian	96	9%	34
Asian	0	0%	9
Pacific Islander	0	0%	9
Some Other Race	94	9%	61
Population Reporting Two or More Races	154	15%	53
Total Hispanic Population	143	14%	68
Total Non-Hispanic Population	881		
White Alone	635	62%	79
Black Alone	4	0%	5
American Indian Alone	96	9%	34
Non-Hispanic Asian Alone	0	0%	9
Pacific Islander Alone	0	0%	9
Other Race Alone	0	0%	9
Two or More Races Alone	146	14%	51
Population by Sex			
Male	488	48%	59
Female	536	52%	60
Population by Age			
Age 0-4	133	13%	30
Age 0-17	307	30%	47
Age 18+	717	70%	72
Age 65+	129	13%	30

Data Note: Detail may not sum to totals due to rounding. Hispanic population can be of any race.
N/A means not available. **Source:** U.S. Census Bureau, American Community Survey (ACS) 2013 - 2017 .

EJSCREEN ACS Summary Report

Location: User-specified polygonal location
Ring (buffer): 0-mile radius
Description:

	2013 - 2017 ACS Estimates	Percent	MOE (±)
Population 25+ by Educational Attainment			
Total	620	100%	46
Less than 9th Grade	32	5%	18
9th - 12th Grade, No Diploma	76	12%	26
High School Graduate	266	43%	41
Some College, No Degree	181	29%	35
Associate Degree	52	8%	16
Bachelor's Degree or more	65	10%	24
Population Age 5+ Years by Ability to Speak English			
Total	891	100%	62
Speak only English	763	86%	67
Non-English at Home[1+2+3+4]	128	14%	52
[1]Speak English "very well"	86	10%	37
[2]Speak English "well"	37	4%	27
[3]Speak English "not well"	2	0%	9
[4]Speak English "not at all"	3	0%	10
[3+4]Speak English "less than well"	5	1%	11
[2+3+4]Speak English "less than very well"	42	5%	27
Linguistically Isolated Households*			
Total	9	100%	11
Speak Spanish	9	100%	7
Speak Other Indo-European Languages	0	0%	9
Speak Asian-Pacific Island Languages	0	0%	9
Speak Other Languages	0	0%	9
Households by Household Income			
Household Income Base	402	100%	28
< $15,000	48	12%	16
$15,000 - $25,000	88	22%	28
$25,000 - $50,000	153	38%	33
$50,000 - $75,000	76	19%	23
$75,000 +	37	9%	17
Occupied Housing Units by Tenure			
Total	402	100%	28
Owner Occupied	201	50%	30
Renter Occupied	201	50%	30
Employed Population Age 16+ Years			
Total	739	100%	54
In Labor Force	478	65%	50
Civilian Unemployed in Labor Force	36	5%	21
Not In Labor Force	261	35%	42

Data Note: Datail may not sum to totals due to rounding. Hispanic population can be of anyrace.
N/A means not available. **Source:** U.S. Census Bureau, American Community Survey (ACS)
*Households in which no one 14 and over speaks English "very well" or speaks English only.

EJSCREEN ACS Summary Report

Location: User-specified polygonal location
Ring (buffer): 0-mile radius
Description:

	2013 - 2017 ACS Estimates	Percent	MOE (±)
Population by Language Spoken at Home*			
Total (persons age 5 and above)	907	100%	116
English	834	92%	131
Spanish	48	5%	58
French	0	0%	9
French Creole	N/A	N/A	N/A
Italian	N/A	N/A	N/A
Portuguese	N/A	N/A	N/A
German	0	0%	9
Yiddish	N/A	N/A	N/A
Other West Germanic	N/A	N/A	N/A
Scandinavian	N/A	N/A	N/A
Greek	N/A	N/A	N/A
Russian	N/A	N/A	N/A
Polish	N/A	N/A	N/A
Serbo-Croatian	N/A	N/A	N/A
Other Slavic	N/A	N/A	N/A
Armenian	N/A	N/A	N/A
Persian	N/A	N/A	N/A
Gujarathi	N/A	N/A	N/A
Hindi	N/A	N/A	N/A
Urdu	N/A	N/A	N/A
Other Indic	N/A	N/A	N/A
Other Indo-European	0	0%	9
Chinese	2	0%	5
Japanese	N/A	N/A	N/A
Korean	0	0%	9
Mon-Khmer, Cambodian	N/A	N/A	N/A
Hmong	N/A	N/A	N/A
Thai	N/A	N/A	N/A
Laotian	N/A	N/A	N/A
Vietnamese	0	0%	9
Other Asian	18	2%	31
Tagalog	0	0%	9
Other Pacific Island	N/A	N/A	N/A
Navajo	N/A	N/A	N/A
Other Native American	N/A	N/A	N/A
Hungarian	N/A	N/A	N/A
Arabic	0	0%	9
Hebrew	N/A	N/A	N/A
African	N/A	N/A	N/A
Other and non-specified	6	1%	13
Total Non-English	73	8%	175

Data Note: Detail may not sum to totals due to rounding. Hispanic popultion can be of any race.
N/A meansnot available. **Source:** U.S. Census Bureau, American Community Survey (ACS) 2013 - 2017.
*Population by Language Spoken at Home is available at the census tract summary level and up.

United States Environmental Protection Agency

EJSCREEN Report (Version 2019)

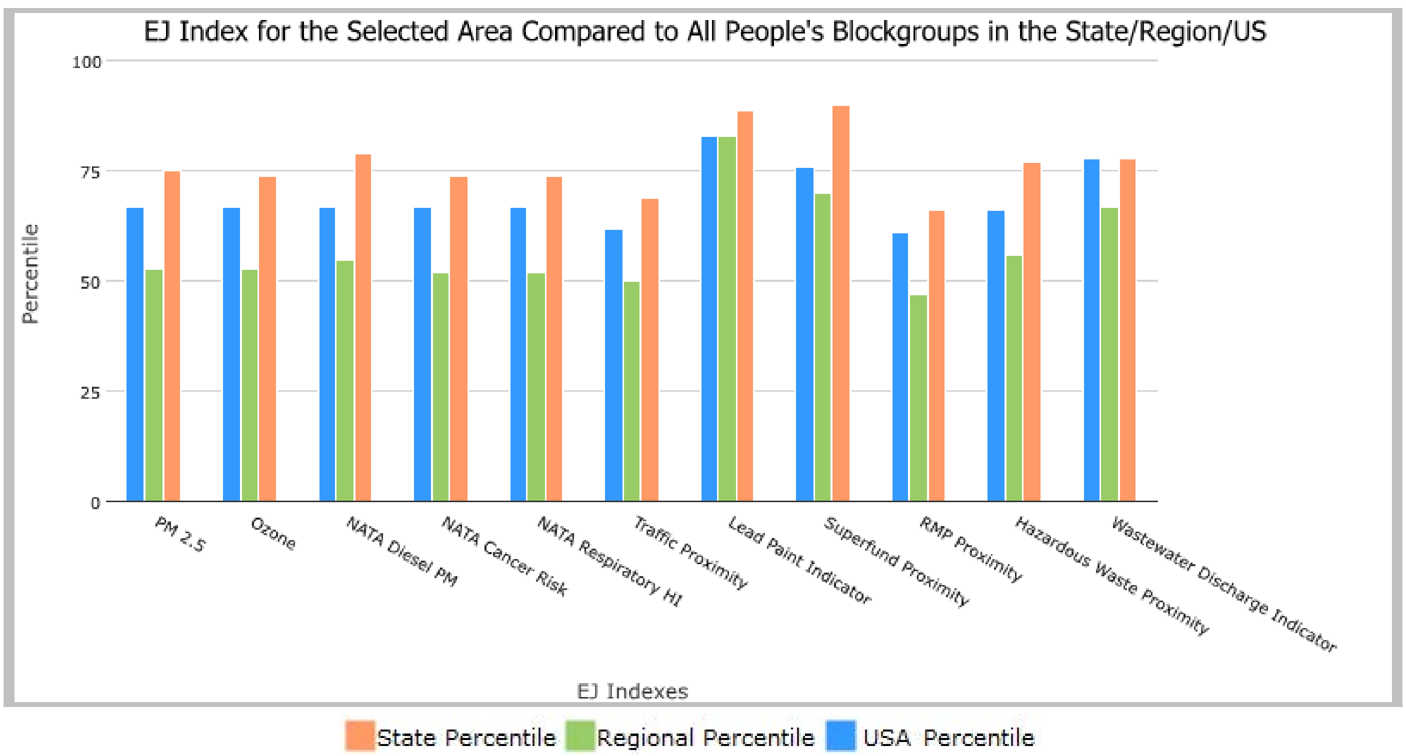
ENVIRONMENTAL JUSTICE

Blockgroup: 401155744003, OKLAHOMA, EPA Region 6

Approximate Population: 1,024

Input Area (sq. miles): 0.19

Selected Variables	State Percentile	EPA Region Percentile	USA Percentile
EJ Indexes			
EJ Index for PM2.5	75	53	67
EJ Index for Ozone	74	53	67
EJ Index for NATA* Diesel PM	79	55	67
EJ Index for NATA* Air Toxics Cancer Risk	74	52	67
EJ Index for NATA* Respiratory Hazard Index	74	52	67
EJ Index for Traffic Proximity and Volume	69	50	62
EJ Index for Lead Paint Indicator	89	83	83
EJ Index for Superfund Proximity	90	70	76
EJ Index for RMP Proximity	66	47	61
EJ Index for Hazardous Waste Proximity	77	56	66
EJ Index for Wastewater Discharge Indicator	78	67	78



This report shows the values for environmental and demographic indicators and EJSCREEN indexes. It shows environmental and demographic raw data (e.g., the estimated concentration of ozone in the air), and also shows what percentile each raw data value represents. These percentiles provide perspective on how the selected block group or buffer area compares to the entire state, EPA region, or nation. For example, if a given location is at the 95th percentile nationwide, this means that only 5 percent of the US population has a higher block group value than the average person in the location being analyzed. The years for which the data are available, and the methods used, vary across these indicators. Important caveats and uncertainties apply to this screening-level information, so it is essential to understand the limitations on appropriate interpretations and applications of these indicators. Please see EJSCREEN documentation for discussion of these issues before using reports.

EJSCREEN Report (Version 2019)

Blockgroup: 401155744003, OKLAHOMA, EPA Region 6

Approximate Population: 1,024

Input Area (sq. miles): 0.19

Sites reporting to EPA	
Superfund NPL	0
Hazardous Waste Treatment, Storage, and Disposal Facilities (TSDF)	0

EJSCREEN Report (Version 2019)

Blockgroup: 401155744003, OKLAHOMA, EPA Region 6

Approximate Population: 1,024

Input Area (sq. miles): 0.19

Selected Variables	Value	State Avg.	%ile in State	EPA Region Avg.	%ile in EPA Region	USA Avg.	%ile in USA
Environmental Indicators							
Particulate Matter (PM 2.5 in µg/m^3)	8.46	8.35	64	8.37	52	8.3	54
Ozone (ppb)	40	43.8	3	39.4	58	43	28
NATA* Diesel PM (µg/m^3)	0.358	0.292	70	0.401	<50th	0.479	<50th
NATA* Cancer Risk (lifetime risk per million)	31	33	24	36	<50th	32	<50th
NATA* Respiratory Hazard Index	0.42	0.45	26	0.45	<50th	0.44	<50th
Traffic Proximity and Volume (daily traffic count/distance to road)	38	210	34	400	23	750	21
Lead Paint Indicator (% Pre-1960 Housing)	0.76	0.24	94	0.17	97	0.28	90
Superfund Proximity (site count/km distance)	0.13	0.05	93	0.081	85	0.13	75
RMP Proximity (facility count/km distance)	0.071	0.57	11	0.82	8	0.74	9
Hazardous Waste Proximity (facility count/km distance)	0.26	0.58	59	0.75	50	4	41
Wastewater Discharge Indicator (toxicity-weighted concentration/m distance)	1.6E-05	0.13	51	9.8	44	14	47
Demographic Indicators							
Demographic Index	47%	36%	78	44%	58	36%	71
Minority Population	38%	34%	68	51%	39	39%	57
Low Income Population	57%	37%	82	37%	78	33%	84
Linguistically Isolated Population	2%	2%	75	6%	49	4%	58
Population With Less Than High School Education	17%	12%	76	16%	62	13%	73
Population Under 5 years of age	13%	7%	94	7%	92	6%	94
Population over 64 years of age	13%	15%	40	13%	56	15%	45

* The National-Scale Air Toxics Assessment (NATA) is EPA's ongoing, comprehensive evaluation of air toxics in the United States. EPA developed the NATA to prioritize air toxics, emission sources, and locations of interest for further study. It is important to remember that NATA provides broad estimates of health risks over geographic areas of the country, not definitive risks to specific individuals or locations. More information on the NATA analysis can be found at: https://www.epa.gov/national-air-toxics-assessment.

For additional information, see: www.epa.gov/environmentaljustice

Reference 10 Population and Wetlands Memorandum

MEMORANDUM

DATE: December 29, 2020

TO: Goodrich Asbestos Impoundment PA/SI File

FROM: Hal Cantwell
Environmental Programs Specialist

RE: Population and Wetlands within ¼, ½, 1, 2, 3, and 4-mile radius of the Goodrich Asbestos Impoundment, Ottawa County, Miami Oklahoma

Population and wetlands calculations are performed with ArcMap software and a programmed model for determining approximate population and wetlands within the above-mentioned distances from the site.

Population:
The following data is from United States (U.S.) Census Bureau (2010).

Distance (miles)	Population
onsite	0
0-.25	0
0-.5	897
0-1	4320
0-2	11451
0-3	15118
0-4	17556

The acreage of wetlands within a four-mile radius of the site delineated in a table below. The following data is published by the U.S. Fish and Wildlife Service from the National Wetlands Inventory.

Distance (miles)	Estimated Wetland Acreage
onsite	0
0-.25	19
0-.5	153
0-1	1330
0-2	3266
0-3	43045
0-4	5327

Reference 11 Threatened and Endangered Species

Ottawa County Threatened and Endangered Species

State-listed Threatened and Endangered Species:

Neosho Mucket (Lampsilis rafinesqueana)

Federal-listed Threatened and Endangered Species:

Official county lists of federally threatened and endangered species are maintained by the U.S. Fish and

Wildlife Service, the federal agency that administers the Endangered Species Act in Oklahoma. Please contact

the U.S. Fish and Wildlife Service for the most accurate and current information. Federally listed endangered

and threatened species in this county may include:

Gray Bat (Myotis grisescens) – endangered

Ozark Big-eared Bat (Corynorhinus (= Plecotus) townsendii ingens) - endangered

Interior Least Tern (Sterna antillarum) - endangered

Piping Plover (Charadrius melodus) – threatened

Neosho Madtom (Noturus placidus) – threatened

Ozark Cavefish (Amblyopsis rosae) - threatened

Arkansas Dater (Etheostoma cragini) – candidate species under evaluation

the U.S. Fish and Wildlife Service for the most accurate and current information. Federally listed endangered

and threatened species in this county may include:

Whooping Crane (Grus americana) – endangered

Object Description

Okla State Agency

Wildlife Conservation, Oklahoma Department of

Okla Agency Code

'320'

Title County by county list of endangered and threatened species.

Alternative title State listed by county

Authors Oklahoma. Department of Wildlife Conservation.

Publisher Oklahoma Department of Wildlife Conservation

Publication Date

2010

Publication Type

Directory

Subject

Endangered species--Oklahoma.

Purpose

Wildlife species may be classified as threatened or endangered at either the state or the federal (national) level.; Nationally, a species may be listed as threatened or endangered throughout its range under the authority of the Endangered Species Act, which is a federal law enacted in the early 1970s. At the present time, 16 wildlife species within the state of Oklahoma are listed as federally threatened or endangered. The U.S. Fish and Wildlife Service is the federal agency that administers the Endangered Species Act. ; The State of Oklahoma has an endangered species statute that gives the state the authority to list a wildlife species as threatened or endangered within the state of Oklahoma although it might not be classified as threatened or endangered federally through the Endangered Species Act. At the present time, four (4) wildlife species are listed as state-threatened or state-endangered in Oklahoma.; by county: State-listed Threatened and Endangered Species; Federal-listed Threatened and Endangered Species

OkDocs Class#

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Digital Format

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ODL electronic copy

Rights and Permissions

Language

English

OCLC number

890219238

Date created

2018-01-05

Date modified

2018-01-05

IPaC resource list

This report is an automatically generated list of species and other resources such as critical habitat (collectively referred to as *trust resources*) under the U.S. Fish and Wildlife Service's (USFWS) jurisdiction that are known or expected to be on or near the project area referenced below. The list may also include trust resources that occur outside of the project area, but that could potentially be directly or indirectly affected by activities in the project area. However, determining the likelihood and extent of effects a project may have on trust resources typically requires gathering additional site-specific (e.g., vegetation/species surveys) and project-specific (e.g., magnitude and timing of proposed activities) information.

Below is a summary of the project information you provided and contact information for the USFWS office(s) with jurisdiction in the defined project area. Please read the introduction to each section that follows (Endangered Species, Migratory Birds, USFWS Facilities, and NWI Wetlands) for additional information applicable to the trust resources addressed in that section.

Location

Craig and Ottawa counties, Oklahoma

Local office

Oklahoma Ecological Services Field Office

(918) 581-7458
(918) 581-7467

9014 East 21st Street
Tulsa, OK 74129-1428

http://www.fws.gov/southwest/es/Oklahoma/

Endangered species

This resource list is for informational purposes only and does not constitute an analysis of project level impacts.

The primary information used to generate this list is the known or expected range of each species. Additional areas of influence (AOI) for species are also considered. An AOI includes areas outside of the species range if the species could be indirectly affected by activities in that area (e.g., placing a dam upstream of a fish population, even if that fish does not occur at the dam site, may indirectly impact the species by reducing or eliminating water flow downstream). Because species can move, and site conditions can change, the species on this list are not guaranteed to be found on or near the project area. To fully determine any potential effects to species, additional site-specific and project-specific information is often required.

Section 7 of the Endangered Species Act **requires** Federal agencies to "request of the Secretary information whether any species which is listed or proposed to be listed may be present in the area of such proposed action" for any project that is conducted, permitted, funded, or licensed by any Federal agency. A letter from the local office and a species list which fulfills this requirement can **only** be obtained by requesting an official species list from either the Regulatory Review section in IPaC (see directions below) or from the local field office directly.

For project evaluations that require USFWS concurrence/review, please return to the IPaC website and request an official species list by doing the following:

1. Draw the project location and click CONTINUE.
2. Click DEFINE PROJECT.
3. Log in (if directed to do so).
4. Provide a name and description for your project.
5. Click REQUEST SPECIES LIST.

Listed species[1] and their critical habitats are managed by the Ecological Services Program of the U.S. Fish and Wildlife Service (USFWS) and the fisheries division of the National Oceanic and Atmospheric Administration (NOAA Fisheries[2]).

Species and critical habitats under the sole responsibility of NOAA Fisheries are **not** shown on this list. Please contact NOAA Fisheries for species under their jurisdiction.

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1. Species listed under the Endangered Species Act are threatened or endangered; IPaC also shows species that are candidates, or proposed, for listing. See the listing status page for more information.
2. NOAA Fisheries, also known as the National Marine Fisheries Service (NMFS), is an office of the National Oceanic and Atmospheric Administration within the Department of Commerce.

The following species are potentially affected by activities in this location:

Mammals

NAME	STATUS
Gray Bat Myotis grisescens No critical habitat has been designated for this species. https://ecos.fws.gov/ecp/species/6329	Endangered
Northern Long-eared Bat Myotis septentrionalis No critical habitat has been designated for this species. https://ecos.fws.gov/ecp/species/9045	Threatened

Ozark Big-eared Bat Corynorhinus (=Plecotus) townsendii ingens — Endangered

No critical habitat has been designated for this species.
https://ecos.fws.gov/ecp/species/7245

Birds

NAME	STATUS
Least Tern Sterna antillarum	Endangered

This species only needs to be considered if any of the following conditions apply:

- Towers (i.e. radio, television, cellular, microwave, meterological)
- Wind Turbines and Wind Farms

No critical habitat has been designated for this species.
https://ecos.fws.gov/ecp/species/8505

Piping Plover Charadrius melodus	Threatened

There is **final** critical habitat for this species. Your location is outside the critical habitat.
https://ecos.fws.gov/ecp/species/6039

Red Knot Calidris canutus rufa	Threatened

No critical habitat has been designated for this species.
https://ecos.fws.gov/ecp/species/1864

Fishes

NAME	STATUS
Neosho Madtom Noturus placidus	Threatened

No critical habitat has been designated for this species.
https://ecos.fws.gov/ecp/species/2577

Ozark Cavefish Amblyopsis rosae	Threatened

No critical habitat has been designated for this species.
https://ecos.fws.gov/ecp/species/6490

Clams

NAME	STATUS
Neosho Mucket Lampsilis rafinesqueana	Endangered

There is **final** critical habitat for this species. Your location is outside the critical habitat.
https://ecos.fws.gov/ecp/species/3788

Insects

NAME	STATUS
American Burying Beetle Nicrophorus americanus	Endangered

No critical habitat has been designated for this species.
https://ecos.fws.gov/ecp/species/66

Critical habitats

Potential effects to critical habitat(s) in this location must be analyzed along with the endangered species themselves.

THERE ARE NO CRITICAL HABITATS AT THIS LOCATION.

Migratory birds

Certain birds are protected under the Migratory Bird Treaty Act[1] and the Bald and Golden Eagle Protection Act[2].

Any person or organization who plans or conducts activities that may result in impacts to migratory birds, eagles, and their habitats should follow appropriate regulations and consider implementing appropriate conservation measures, as described below.

1. The Migratory Birds Treaty Act of 1918.
2. The Bald and Golden Eagle Protection Act of 1940.

Additional information can be found using the following links:

- Birds of Conservation Concern http://www.fws.gov/birds/management/managed-species/birds-of-conservation-concern.php
- Measures for avoiding and minimizing impacts to birds http://www.fws.gov/birds/management/project-assessment-tools-and-guidance/conservation-measures.php
- Nationwide conservation measures for birds http://www.fws.gov/migratorybirds/pdf/management/nationwidestandardconservationmeasures.pdf

The birds listed below are birds of particular concern either because they occur on the USFWS Birds of Conservation Concern (BCC) list or warrant special attention in your project location. To learn more about the levels of concern for birds on your list and how this list is generated, see the FAQ below. This is not a list of every bird you may find in this location, nor a guarantee that every bird on this list will be found in your project area. To see exact locations of where birders and the general public have sighted birds in and around your project area, visit the E-bird data mapping tool (Tip: enter your location, desired date range and a species on your list). For projects that occur off the Atlantic Coast, additional maps and models detailing the relative occurrence and abundance of bird species on your list are available. Links to additional information about Atlantic Coast birds, and other important information about your migratory bird list, including how to properly interpret and use your migratory bird report, can be found below.

For guidance on when to schedule activities or implement avoidance and minimization measures to reduce impacts to migratory birds on your list, click on the PROBABILITY OF PRESENCE SUMMARY at the top of your list to see when these birds are most likely to be present and breeding in your project area.

NAME	BREEDING SEASON (IF A BREEDING SEASON IS INDICATED FOR A BIRD ON YOUR LIST, THE BIRD MAY BREED IN YOUR PROJECT AREA SOMETIME WITHIN THE TIMEFRAME SPECIFIED, WHICH IS A VERY LIBERAL ESTIMATE OF THE DATES INSIDE WHICH THE BIRD BREEDS ACROSS ITS ENTIRE RANGE. "BREEDS ELSEWHERE" INDICATES THAT THE BIRD DOES NOT LIKELY BREED IN YOUR PROJECT AREA.)

Bald Eagle Haliaeetus leucocephalus

Breeds Oct 15 to Aug 31

This is not a Bird of Conservation Concern (BCC) in this area, but warrants attention because of the Eagle Act or for potential susceptibilities in offshore areas from certain types of development or activities.
https://ecos.fws.gov/ecp/species/1626

Prothonotary Warbler Protonotaria citrea

Breeds Apr 1 to Jul 31

This is a Bird of Conservation Concern (BCC) throughout its range in the continental USA and Alaska.

Rusty Blackbird Euphagus carolinus

Breeds elsewhere

This is a Bird of Conservation Concern (BCC) throughout its range in the continental USA and Alaska.

Probability of Presence Summary

The graphs below provide our best understanding of when birds of concern are most likely to be present in your project area. This information can be used to tailor and schedule your project activities to avoid or minimize impacts to birds. Please make sure you read and understand the FAQ "Proper Interpretation and Use of Your Migratory Bird Report" before using or attempting to interpret this report.

Probability of Presence (■)

Each green bar represents the bird's relative probability of presence in the 10km grid cell(s) your project overlaps during a particular week of the year. (A year is represented as 12 4-week months.) A taller bar indicates a higher probability of species presence. The survey effort (see below) can be used to establish a level of confidence in the presence score. One can have higher confidence in the presence score if the corresponding survey effort is also high.

How is the probability of presence score calculated? The calculation is done in three steps:

1. The probability of presence for each week is calculated as the number of survey events in the week where the species was detected divided by the total number of survey events for that week. For example, if in week 12 there were 20 survey events and the Spotted Towhee was found in 5 of them, the probability of presence of the Spotted Towhee in week 12 is 0.25.
2. To properly present the pattern of presence across the year, the relative probability of presence is calculated. This is the probability of presence divided by the maximum probability of presence across all weeks. For example, imagine the probability of presence in week 20 for the Spotted Towhee is 0.05, and that the probability of presence at week 12 (0.25) is the maximum of any week of the year. The relative probability of presence on week 12 is 0.25/0.25 = 1; at week 20 it is 0.05/0.25 = 0.2.
3. The relative probability of presence calculated in the previous step undergoes a statistical conversion so that all possible values fall between 0 and 10, inclusive. This is the probability of presence score.

To see a bar's probability of presence score, simply hover your mouse cursor over the bar.

Breeding Season (■)
Yellow bars denote a very liberal estimate of the time-frame inside which the bird breeds across its entire range. If there are no yellow bars shown for a bird, it does not breed in your project area.

Survey Effort (|)
Vertical black lines superimposed on probability of presence bars indicate the number of surveys performed for that species in the 10km grid cell(s) your project area overlaps. The number of surveys is expressed as a range, for example, 33 to 64 surveys.

To see a bar's survey effort range, simply hover your mouse cursor over the bar.

No Data (–)
A week is marked as having no data if there were no survey events for that week.

Survey Timeframe

Surveys from only the last 10 years are used in order to ensure delivery of currently relevant information. The exception to this is areas off the Atlantic coast, where bird returns are based on all years of available data, since data in these areas is currently much more sparse.

Tell me more about conservation measures I can implement to avoid or minimize impacts to migratory birds.

Nationwide Conservation Measures describes measures that can help avoid and minimize impacts to all birds at any location year round. Implementation of these measures is particularly important when birds are most likely to occur in the project area. When birds may be breeding in the area, identifying the locations of any active nests and avoiding their destruction is a very helpful impact minimization measure. To see when birds are most likely to occur and be breeding in your project area, view the Probability of Presence Summary. Additional measures and/or permits may be advisable depending on the type of activity you are conducting and the type of infrastructure or bird species present on your project site.

What does IPaC use to generate the migratory birds potentially occurring in my specified location?

The Migratory Bird Resource List is comprised of USFWS Birds of Conservation Concern (BCC) and other species that may warrant special attention in your project location.

The migratory bird list generated for your project is derived from data provided by the Avian Knowledge Network (AKN). The AKN data is based on a growing collection of survey, banding, and citizen science datasets and is queried and filtered to return a list of those birds reported as occurring in the 10km grid cell(s) which your project intersects, and that have been identified as warranting special attention because they are a BCC species in that area, an eagle (Eagle Act requirements may apply), or a species that has a particular vulnerability to offshore activities or development.

Again, the Migratory Bird Resource list includes only a subset of birds that may occur in your project area. It is not representative of all birds that may occur in your project area. To get a list of all birds potentially present in your project area, please visit the AKN Phenology Tool.

What does IPaC use to generate the probability of presence graphs for the migratory birds potentially occurring in my specified location?

The probability of presence graphs associated with your migratory bird list are based on data provided by the Avian Knowledge Network (AKN). This data is derived from a growing collection of survey, banding, and citizen science datasets .

Probability of presence data is continuously being updated as new and better information becomes available. To learn more about how the probability of presence graphs are produced and how to interpret them, go the Probability of Presence Summary and then click on the "Tell me about these graphs" link.

How do I know if a bird is breeding, wintering, migrating or present year-round in my project area?

To see what part of a particular bird's range your project area falls within (i.e. breeding, wintering, migrating or year-round), you may refer to the following resources: The Cornell Lab of Ornithology All About Birds Bird Guide, or (if you are unsuccessful in locating the bird of interest there), the Cornell Lab of Ornithology Neotropical Birds guide. If a bird on your migratory bird species list has a breeding season associated with it, if that bird does occur in your project area, there may be nests present at some point within the timeframe specified. If "Breeds elsewhere" is indicated, then the bird likely does not breed in your project area.

What are the levels of concern for migratory birds?

Migratory birds delivered through IPaC fall into the following distinct categories of concern:

1. "BCC Rangewide" birds are Birds of Conservation Concern (BCC) that are of concern throughout their range anywhere within the USA (including Hawaii, the Pacific Islands, Puerto Rico, and the Virgin Islands);
2. "BCC - BCR" birds are BCCs that are of concern only in particular Bird Conservation Regions (BCRs) in the continental USA; and
3. "Non-BCC - Vulnerable" birds are not BCC species in your project area, but appear on your list either because of the Eagle Act requirements (for eagles) or (for non-eagles) potential susceptibilities in offshore areas from certain types of development or activities (e.g. offshore energy development or longline fishing).

Although it is important to try to avoid and minimize impacts to all birds, efforts should be made, in particular, to avoid and minimize impacts to the birds on this list, especially eagles and BCC species of rangewide concern. For more information on conservation measures you can implement to help avoid and minimize migratory bird impacts and requirements for eagles, please see the FAQs for these topics.

Details about birds that are potentially affected by offshore projects

For additional details about the relative occurrence and abundance of both individual bird species and groups of bird species within your project area off the Atlantic Coast, please visit the Northeast Ocean Data Portal. The Portal also offers data and information about other taxa besides birds that may be helpful to you in your project review. Alternately, you may download the bird model results files underlying the portal maps through the NOAA NCCOS Integrative Statistical Modeling and Predictive Mapping of Marine Bird Distributions and Abundance on the Atlantic Outer Continental Shelf project webpage.

Bird tracking data can also provide additional details about occurrence and habitat use throughout the year, including migration. Models relying on survey data may not include this information. For additional information on marine bird tracking data, see the Diving Bird Study and the nanotag studies or contact Caleb Spiegel or Pam Loring.

What if I have eagles on my list?

If your project has the potential to disturb or kill eagles, you may need to obtain a permit to avoid violating the Eagle Act should such impacts occur.

Proper Interpretation and Use of Your Migratory Bird Report

The migratory bird list generated is not a list of all birds in your project area, only a subset of birds of priority concern. To learn more about how your list is generated, and see options for identifying what other birds may be in your project area, please see the FAQ "What does IPaC use to generate the migratory birds potentially occurring in my specified location". Please be aware this report provides the "probability of presence" of birds within the 10 km grid cell(s) that overlap your project; not your exact project footprint. On the graphs provided, please also look carefully at the survey effort (indicated by the black vertical bar) and for the existence of the "no data" indicator (a red horizontal bar). A high survey effort is the key component. If the survey effort is high, then the probability of presence score can be viewed as more dependable. In contrast, a low survey effort bar or no data bar means a lack of data and, therefore, a lack of certainty about presence of the species. This list is not perfect; it is simply a starting point for identifying what birds of concern have the potential to be in your project area, when they might be there, and if they might be breeding (which means nests might be present). The list helps you know what to look for to confirm presence, and helps guide you in knowing when to implement conservation measures to avoid or minimize potential impacts from your project activities, should presence be confirmed. To learn more about conservation measures, visit the FAQ "Tell me about conservation measures I can implement to avoid or minimize impacts to migratory birds" at the bottom of your migratory bird trust resources page.

Facilities

National Wildlife Refuge lands

Any activity proposed on lands managed by the National Wildlife Refuge system must undergo a 'Compatibility Determination' conducted by the Refuge. Please contact the individual Refuges to discuss any questions or concerns.

THERE ARE NO REFUGE LANDS AT THIS LOCATION.

Fish hatcheries

THERE ARE NO FISH HATCHERIES AT THIS LOCATION.

Wetlands in the National Wetlands Inventory

Impacts to NWI wetlands and other aquatic habitats may be subject to regulation under Section 404 of the Clean Water Act, or other State/Federal statutes.

For more information please contact the Regulatory Program of the local U.S. Army Corps of Engineers District.

Please note that the NWI data being shown may be out of date. We are currently working to update our NWI data set. We recommend you verify these results with a site visit to determine the actual extent of wetlands on site.

This location overlaps the following wetlands:

> The area of this project is too large for IPaC to load all NWI wetlands in the area. The list below may be incomplete. Please contact the local U.S. Fish and Wildlife Service office or visit the NWI map for a full list.

FRESHWATER EMERGENT WETLAND

- PEM1A
- PEM1C
- PEM1Ah
- PEM1Ch
- PEM1Cx
- PEM1Fx
- PEM1Cd
- PEM1F
- PEM1Ax

FRESHWATER FORESTED/SHRUB WETLAND

- PFO1A
- PFO1C
- PSS1A
- PFO1F
- PSS1C
- PSS1F
- PFO1Ch
- PFO1Ah

PFO1Ax
PSS1Cx
PSS1Ah
PSS1Ad
PSS1Ch
PSS1Ax
PFO1Cx

FRESHWATER POND

PUBHh
PUBHx
PUBH
PUBFx
PUBFh

A full description for each wetland code can be found at the National Wetlands Inventory website

Data limitations

The Service's objective of mapping wetlands and deepwater habitats is to produce reconnaissance level information on the location, type and size of these resources. The maps are prepared from the analysis of high altitude imagery. Wetlands are identified based on vegetation, visible hydrology and geography. A margin of error is inherent in the use of imagery; thus, detailed on-the-ground inspection of any particular site may result in revision of the wetland boundaries or classification established through image analysis.

The accuracy of image interpretation depends on the quality of the imagery, the experience of the image analysts, the amount and quality of the collateral data and the amount of ground truth verification work conducted. Metadata should be consulted to determine the date of the source imagery used and any mapping problems.

Wetlands or other mapped features may have changed since the date of the imagery or field work. There may be occasional differences in polygon boundaries or classifications between the information depicted on the map and the actual conditions on site.

Data exclusions

Certain wetland habitats are excluded from the National mapping program because of the limitations of aerial imagery as the primary data source used to detect wetlands. These habitats include seagrasses or submerged aquatic vegetation that are found in the intertidal and subtidal zones of estuaries and nearshore coastal waters. Some deepwater reef communities (coral or tuberficid worm reefs) have also been excluded from the inventory. These habitats, because of their depth, go undetected by aerial imagery.

Data precautions

Federal, state, and local regulatory agencies with jurisdiction over wetlands may define and describe wetlands in a different manner than that used in this inventory. There is no attempt, in either the design or products of this inventory, to define the limits of proprietary jurisdiction of any Federal, state, or local government or to establish the geographical scope of the regulatory programs of government agencies. Persons intending to engage in activities involving modifications within or adjacent to wetland areas should seek the advice of appropriate federal, state, or local agencies concerning specified agency regulatory programs and proprietary jurisdictions that may affect such activities.